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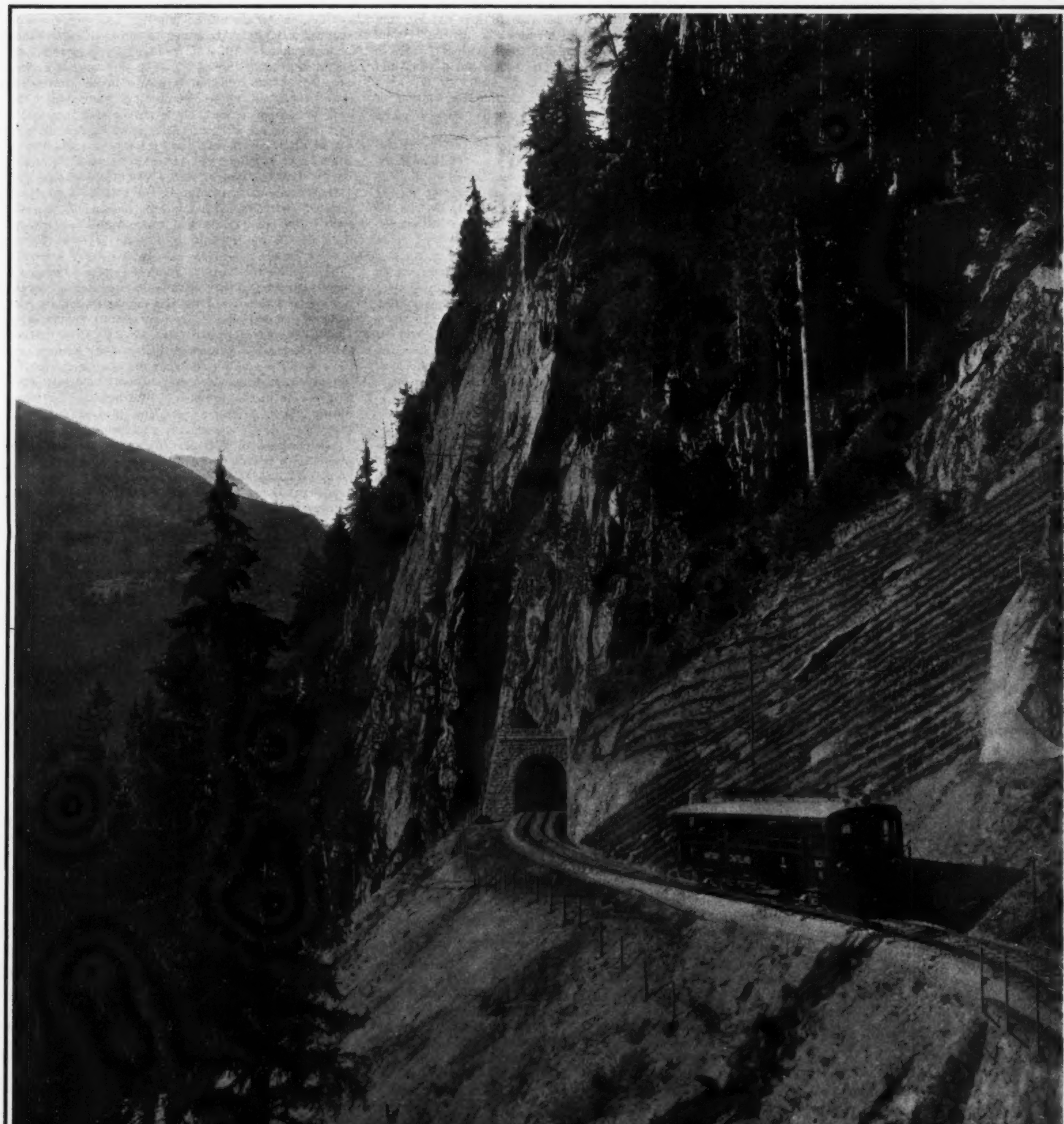

A PICTURESQUE SECTION OF THE MARTIGNY-CHATELARD LINE.

A NEW SWISS MOUNTAIN ROAD.—[SEE PAGE 376.]

CHEMISTRY OF THE STEAM BOILER.

THE SCIENCE OF STEAM GENERATION.

BY DR. E. E. BASCH.

At the seventh International Congress of Applied Chemistry held at London (1909) O. N. Witt of Berlin spoke on the "Application of the Biological Concept of Evolution to the Progress of Applied Chemistry." He began with the idea that the law of evolution is applicable not only to living plants and animals, but to everything that is capable of growth, change, and improvement, and therefore to science in general and to applied chemistry in particular. He said that the development of the chemical industry also was governed by the biological laws of adaptation, of the principle of economy, of symbiosis, etc. According to Witt, scientific chemistry is comparatively recent, but applied chemistry has existed from time immemorial. Experiment and experience were the first sign-posts for the slow but sure progress in the development of applied chemistry, but modern chemical science has become a guide to much more rapid advance, by explaining old well-known facts and showing new ways to novel or improved results.

These general remarks are applicable to every branch of industries. The considerations following below deal with a branch the prominence of which is indicated by its great extent: the generation of steam. Since the introduction of the steam engine, the importance of steam generation has increased constantly. The operation of steam boilers has so many features involving chemical action that it is rather surprising to note the long-continued absence of chemical research in this field. From the point of view of evolution, this neglect is readily explainable. Notwithstanding its indispensableness, steam generation, considered as part of the entire industrial process, forms only an auxiliary step. The efficiency of steam generation did not become a vital question until the advent of our industrial era, when wages and fuel prices (owing to rising demand) constantly increased, and fierce competition compelled extreme economy in every department of manufacture. Conditions having created a want, empirical efforts at improvement were first made, the problem being attacked from two sides as suggested by the two most important factors in the operation of steam boilers: fire and water. The chemist did not press to the fore to solve this purely practical problem. The philosophical origin of chemistry is probably the reason why its theories are either far in advance of the times or far behind. The rapid interaction and mutual fructification of theory and practice observable in our days were not possible until the laboratory test had been acknowledged as the foundation of all theory and likewise as the touchstone of practical work. It is well known that rising Germany has had a leading part in this appreciation of experimental research.

Nowadays it is universally conceded that the economical utilization of fuel is hardly possible without the aid of chemical investigations. Witt has shown that the question of heating is intimately connected with the carrying out of the economic principle. The tests as to utilization of coal are still made almost exclusively by engineers and mechanics, although they are based on chemical determinations; the chemical analysis of the fuel (raw material) on one hand and of the smoke gases (waste product) on the other hand.

It is not surprising that the attack on boiler scale should have begun with unscientific "home" remedies. Stokers would put potatoes, wood shavings, or vegetable extracts into the mud drum in order to prevent the crystallization of boiler scale. When the feed water was not very hard, this result was attained sometimes, but the boiler mud then formed, which was permeated by organic substances, would injure the boiler much more than boiler scale, by overheating of the sheets and obstruction of the water passages, not to mention the danger attending the presence of solid foreign bodies in the boiler. Notwithstanding this serious objection, a thriving business is still being done in so-called anti-boiler-scale compounds, the constitution of which is kept secret.

In the last few decades the chemical purification of water has made great headway. Hard well water and spring water, contaminated river water and oil-bearing condensation water have been softened and purified by the addition of chemicals, settling and filtration, before their use as feed water for boilers. A large number of processes were developed and introduced on a scientific basis, very often against the opposition of the "old practical men." The modern literature of this industry has also dealt frequently with the building up of this branch.

The manufacturer and his technical staff as a rule consider the engineer of the boiler inspection association an expert on the chemical action of the feed water and its constituents which lead to the formation of boiler scale and to the corrosion of boiler parts. Quite often the inspecting engineer will also be consulted concerning questions of water purification. In view of these conditions there is urgent need of attaching to the staff of every big inspection association a chemical specialist who will be able to give information to his colleagues and to members of the association. This specialist should keep in touch with the progress of chemical research regarding water purification and with practical improvements as well. So far as I know, only the Bavarian inspection association of Munich employs a chemist as a regular member of its staff.

These official circles are well aware of the importance of developing the chemical phase of their activity, as is evidenced by the occasional selection of chemical subjects for lectures at the annual meetings of the International Union of Steam Boiler Inspection Associations. In the minutes of the thirty-seventh meeting of delegates (Boysen & Maasch, publishers, Hamburg, 1907) there is contained, among others, a paper of this character by Dr. Aufhäuser of Hamburg, which will be of considerable interest to the chemist also: "Water in the Light of New Theories, with Especial Reference to the Operation of Steam Boilers." This is reproduced as an article in No. 6, 1908, of the Zeitschrift der Dampfkesseluntersuchungs- und Versicherungs-Gesellschaft A.-G., of Vienna. Readers of Zeitschrift für angewandte Chemie will find an abstract on pages 301 and 302 of the 1908 volume.

At the end of his paper Dr. Aufhäuser mentions the practical conclusions for boiler operation which are derived from physico-chemical considerations. As regards purification of water, he insists that all data of operating conditions should be taken into account. This view will be concurred in universally. But going further, Aufhäuser promises that the chemist will be able to calculate the time when the boiler should be emptied, whereas hitherto this time was determined by practical considerations only. According to Aufhäuser, the only data required for the calculation are: boiler capacity, pressure, temperature, and quantity of water converted into steam. "These factors being known, it is possible to figure with absolute accuracy at what time supersaturation will have proceeded so far that boiler scale will be deposited or that the concentration will affect the boiler walls injuriously."

This is indeed a proud announcement. How far may we hope to see it realized in practice? The prevention of boiler scale by a timely renewal of the water is possible only in the case of the relatively rare "water-soluble" type of boiler scale. Natural or softened feed water which is unusually rich in common salt or in sodium sulphate, will sometimes cause supersaturation of these salts in the boiler water within the usual periods of operation. The result is a salty boiler scale which is just as hard and solid as ordinary boiler scale. I have discussed such occurrences in the Zeitschrift des Bayrischen Revisionsvereines, 1906, No. 7, and 1908, No. 24. In cases of this kind it becomes necessary to take from time to time at the gage glass samples of the boiler water, test them with an areometer and avoid exceeding a certain density. Even with average feed water this simple method is advisable as an approximate guide for the proper time of emptying the boiler, and unless there are special reasons, from 1.5 to 2 deg. Bé. should not be exceeded. It is impossible to prevent in this manner the ordinary boiler scale which consists chiefly of calcium sulphate, calcium carbonate, and magnesium compounds, since this boiler scale begins to form the very first day of operation, on account of the exceedingly small solubility of its constituents, which in the case of calcium sulphate, for instance, will be almost 0 at about 150 deg. Centigrade.

Another question is: At what degree of concentration will the corroding salts begin to attack the boiler walls? The foundation and observations necessary to answer this question are still lacking. H. Ost's preliminary work on "the action of magnesium chloride in steam boilers" (Chemiker Zeitung, 1902, 71) has met with contradiction. As regards nitrates and nitrites experience shows it to be very important whether or not the boiler contains stone and mud. With such deposits there will easily occur a local overheating of the sheets and possibly also an enrichment in dissolved salts. The greatest possible security from attack is obtained by first softening the water so as to insure the absence of incrustations and the maintenance of an alkaline reaction of the boiler water. Even then, of course, frequent emptying and partial blowing off of the boiler will be resorted to, but we cannot expect to avoid these corrosions merely by a partial renewing of the boiler contents.

The method of water purification most widely employed hitherto involves the use of soda to remove gypsum. This causes the addition of two new compounds to the salts contained in the feed water, since sodium sulphate will be formed from gypsum and soda, and since a small excess of sodium carbonate is always supplied. The constant evaporation in the boiler causes these salts to become enriched and to enter the cycle of mutual actions. It is well known that under such circumstances bronze fittings which contain zinc will be attacked gradually and the soluble sodium salts will appear as exudations at leaky places. Less familiar is the knowledge of the chemical changes the sodium compounds undergo in the boiler. My further remarks shall deal with two such phenomena or reactions which show the influence of physical action upon the chemical equilibrium.

First: $Na_2CO_3 + H_2O = 2\ NaOH + CO_2$.

In the last few years several observers have noted that this reaction may occur at temperatures prevailing in the boiler. In a treatise on the examination of boiler feed water and the testing of water purification (published by N. Kymmel, Riga, 1903) Prof. C. Blacher called attention to the necessity for being equally cautious with the addition of an excess of soda for purifying purposes, "since soda may be converted into caustic lye even in the presence of bicarbonates, as I have recently found for the second time in a characteristic case."

According to H. Frischer (Chemiker Zeitung, 1906, page 125) a certain feed water was softened with soda and caustic soda, the latter being used in too small quantity, so that the purified water did not show any redness resistant to barium chloride. The interesting fact developed that notwithstanding this, caustic soda had been formed in the boiler water. "The formation of sodium hydroxid could be explained only by a direct dissociation of sodium carbonate or by its decomposition in the presence of iron hydroxid or magnesium hydroxid or basic magnesium carbonate with accompanying formation of normal or basic carbonates of iron and magnesium, which under the influence of heat and pressure split up into carbonic acid and hydroxids and decompose the soda for the second time." The author states that the formation of caustic soda by the decomposition of soda will occur even with a low degree of soda alkalinity (from 0.03 to 0.04 gramme of Na_2CO_3 per liter). Let us say in addition that according to the analysis received the raw feed water had no unusual condition beyond a relatively high percentage of magnesium. This circumstance, however, can hardly be of fundamental importance, particularly in view of the fact that every water after purification contains a magnesia residue increased in percentages relatively to the residual lime contents.

In my own practice I have observed this phenomenon innumerable times. As the first example among many of a like character I will cite a water purifying plant in Lübeck where water is softened with calcined soda and burnt lime. The latter is filled into the well-known conical line saturator and is fed to the impure water in the form of saturated and clarified lime water, simultaneously with the soda solution. In January, 1908, I analyzed a sample of the saturated lime water (taken 11 hours after charging), a sample of the purified water (obtained at the same time), and a sample of the boiler water (taken after the boiler had been in operation six weeks). All the figures given below are approximate and are expressed in calcium carbonate degrees, which (corresponding to the French degrees of hardness) represent the equivalent amount for each 10 milligrammes of $CaCO_3$ (molecular weight, 100) in 1 liter of water.

	Hardness. Deg.	Na_2CO_3. Deg.	NaOH. Deg.
Lime water	212	—	—
Purified water	9	8	0
Boiler water	5	50	250

Therefore, although the red color given to the purified water by adding phenolphthalein disappeared entirely upon the further addition of barium chloride (thus indicating the absence of hydroxyl ions), the boiler contains a considerable amount of caustic soda.

Any generalization of the results of this example might be met with the objection that the sample of

purified water had not been taken until eleven hours after the placing of a fresh charge in the saturator, and that possibly during the first few hours of operation some undissolved particles of caustic lime reached the reaction vessel together with the lime water. By their action on the excess of soda, caustic soda might have been formed temporarily. In view of this objection I shall refer to the conditions found in a second case, a steam boiler plant at Benrath, where samples of water were taken one-half hour and three hours after and a half hour before recharging with chemicals.

	Hardness. Deg.	Na_2CO_3. Deg.	NaOH. Deg.
Three samples of lime water about	240	0	0
Purified water. ½ hour after charging.	2	460	0
Purified water. 3 hours after charging.	4	30	0
Purified water. ½ hour before charging	9	8	0
Boiler water	2	345	730

It will be seen that in this case a great mistake was made as regards the amount of soda added, which explains the unusually large excess of soda in the average constitution of the boiler water. The results also show the abundant formation of caustic soda, while the three samples of the purified water are free from hydroxyl ions and the saturated lime water was found to be clear all day and free from solid particles of caustic lime.

Even more convincing are those cases in which no caustic alkalis at all were used for purifying water, but sulphate of alumina and calcined soda, as in a Wilhelmsburg factory:

	Hardness. Deg.	Na_2CO_3. Deg.	NaOH. Deg.
Purified water	6—7	0	0
Boiler water after 4 weeks	4	8	28
Boiler water after 5 weeks	3	15	52

It was impossible to prove the existence of an excess of soda as such in the purified water, because on account of the evolution of carbonic acid it is present as $NaHCO_3$, which is not turned red by phenolphthalein. Upon heating the purified water will become red, but not until decomposition had taken place in the boiler did the red color become permanent against the action of barium chlorid.

That the simultaneous employment of sulphate of alumina did not affect the reaction is shown by a case observed at Penzig, where the feed water is treated with calcined soda exclusively:

	Hardness. Deg.	Na_2CO_3. Deg.	NaOH. Deg.
Purified water. ½ hour after recharging	9	8	0
Purified water. 3 hours after recharging.	6	17	0
Purified water. ½ hour before recharging	9	8	0
Boiler water after ½ hour	2	145	460

We may therefore consider it as an established fact that under high pressure and a corresponding temperature part of the soda will be converted into NaOH (with simultaneous formation of CO_2) until a condition of equilibrium is attained. It remains for us to ascertain the boiler pressure at which this decomposition will begin. The examples cited above relate to modern boiler installations in which it may be assumed that the pressure during operation amounts to about 10 atmospheres or more.

In one instance (a boiler installation at Luckenau) I did not observe any decomposition of the soda, which was used in excess:

	Hardness. Deg.	Na_2CO_3. Deg.	NaOH. Deg.
Purified water. ½ hour after charging.	18	4	0
Purified water. 3 hours after charging.	10	4	2
Purified water. ½ hour before charging.	14	3	0
Boiler water	3	240	0

This particular boiler was operated under a pressure of 6 atmospheres, corresponding to a temperature of about 160 deg. Centigrade. Judging from this one case, the point at which an excess of soda will be decomposed in the water contents of a steam boiler, lies above 160 deg. Centigrade.

In connection with the results pointed out I wish to make a remark concerning "permutite":

In his paper "On Artificial Zeoliths" (Zeitschrift für angewandte Chemie, vol. 22, 1909, page 1022) Dr. P. Siedler praises the action of these zeoliths by stating that when they are used for softening water, the "permuted" water shows only soda alkalinity, while water purified by lime and soda also exhibits soda-lye alkalinity, "whereby corrosion is caused in the boiler." The statement last quoted is erroneous. Caustic alkalies, like soda, can injure only bronze fittings, but not boiler sheets. Besides, the difference of the various alkalinities is immaterial for the operation of boilers, as will be apparent from my explanations given above. Softening by means of "permutite" yields a feed water whose carbonate hardness has been converted into sodium bicarbonate. The imperfectly bound carbonic acid is then liberated in the boiler, sodium carbonate being formed at the same time, and the carbonic acid further leads to the formation of sodium hydroxid, as has been shown above. It is true the continued introduction of $NaHCO_3$ will repeatedly bring about a certain equalization, since a portion of the imperfectly bound CO_2 will combine with some of the NaOH present, but the total result depends on the operating pressure of the boiler. The lime-soda method offers the possibility of reducing the alkalinities to a minimum by a careful treatment of the water, but with the "permutite" method it is impossible to avoid an increase of the soda alkalinity and of the soda-lye alkalinity of the boiler water.

Here I may also incidentally refer to the question of cost. Dr. Siedler says that in the case of a particular water the purification of 1 cubic meter according to the "permutite" method cost 2.8 pfennigs (0.7 cent) but that with the lime-soda method the cost would be 3.5 pfennigs (0.9 cent). He does not say, however, what reason he has for assuming this latter figure. As the total hardness of the water in question is 20 deg. of the German scale, and as the carbonate hardness constitutes one half of this, or 10 degrees of the German scale, the following maximum additions may be calculated (even taking into account a very high magnesia hardness):

Two hundred grammes of soda and about 200 grammes of caustic lime for each cubic meter of water. If the market price of 98 to 100 per cent calcined soda is taken as 12 marks ($3) per 100 kilogrammes and that of burnt lime is 2 marks (50 cents)—both are obtainable even cheaper, except at retail—the cost cannot be made to exceed 2.8 pfennigs (0.7 cent). The figure 3.5 on which Dr. Siedler bases his further comparison of costs must therefore have been derived from erroneous assumptions.

Second: $Na_2SO_4 + CaCO_3 \rightleftarrows Na_2CO_3 + CaSO_4$.

This equation, if read from right to left, represents the reaction taking place when water containing gypsum is softened in the usual way with soda. It is well known that the precipitation is not complete but that conditions will tend toward an equilibrium. Softened water always possesses a residual degree of hardness, even when chemicals are added in excess. This fact alone indicates the possibility that under suitable conditions the reaction may be reversed. The degree of final or residual hardness may be reduced, within certain limits, by physical expedients:

1. By increasing the temperature (heating the water during its purification); 2, by increasing the length of the reaction period (enlarging the reaction chamber or storage vessel); 3, by using large volumes (providing chemicals in excess, intentionally). Other factors which have not been investigated particularly as yet and which are of secondary importance, are: 4, purification of the water mixture; 5, thorough mixing; 6, presence of mud left from previous operations.

I have not found in the literature any disclosure of the fact that the above equation may proceed from left to right in the boiler; that is to say, under certain conditions a re-formation of gypsum may take place so that boiler scale will be found notwithstanding thorough softening of the water. Mud containing $CaCO_3$ is always present in the boiler, for the last remnants of the hardening substances are precipitated only in the boiler. Sodium sulphate remains in solution in the purified water, and its concentration in the boiler water is constantly increased as evaporation progresses. According to the law of mass effect, this increase in sodium sulphate contents tends to give calcium sulphate stability in the presence of sodium carbonate.

In an electric central station where boiler scale was complained of, notwithstanding water purification, I found the following figures (calcium carbonate degrees):

	Hardness. Deg.	Na_2CO_3. Deg.	NaOH. Deg.
Purified water	7—8	15	2
Boiler water	17	40	210

The purified water was analyzed several times a day, the result being about the same. Qualitative analysis showed that the boiler water had been greatly enriched in sodium sulphate and sodium chloride. This offers the only explanation for the fact that the boiler water (taken hot at the gage glass cock) was harder than the purified water (under normal conditions the contrary is always the case) and that gypsum scale was formed notwithstanding the addition of a sufficient amount of soda.

In a textile factory similar conditions were found:

	Hardness. Deg.	Na_2CO_3. Deg.	NaOH. Deg.
Boiler water	19	45	72

This particular boiler had been in operation with purified water day and night for eight weeks without being cleaned once during this entire period. The sodium sulphate contents corresponded to more than 200 calcium carbonate degrees. The scales consisted chiefly of gypsum. As soon as the boiler water was renewed regularly, the formation of scale ceased. It was found sufficient to empty the boiler once a week of the water contained between the upper and the lower marks of the gage glass.

Another investigator found the following figures in a similar case (milligrammes per liter):

	Impure water (well water).	Boiler water (of a specific gravity of 1.07 at 15 deg. C.)
CaO	310.4	72.8
MgO	90.2	4.6
SO_3	370.4	5100.3
Cl	78.0	2960.3
N_2O_5	present	very abundant
N_2O_3	0	present
Total hardness	78 deg. of the French scale.	14.2 deg. of the French scale
Na_2CO_3	—	134.8

In this case also, therefore, we find, notwithstanding unspent soda (12.7 deg) a total hardness (14.2 deg French) sufficient to lead to the formation of boiler scale and also a very considerable amount of sodium sulphate (637.5 $CaCO_3$ deg.). If boiler water from feed water containing gypsum shows a hardness exceeding from 8 to 10 degrees (French) for any length of time, the formation of boiler scale may be expected almost with certainty. According to samples previously obtained, the scale in this particular case consisted chiefly of calcium carbonate and calcium sulphate.

Finally a laboratory experiment was made in order to determine the possibility of $CaSO_4$ and Na_2CO_3 being formed from the reciprocal pair of salts even when heating without pressure. This supposition was confirmed. Two grammes of pure precipitated calcium carbonate were boiled with 200 cubic centimeters of distilled water. The resulting liquid was colored a light pink by phenolphthalein, owing to a slight dissociation of $CaCO_3$. Then a few grammes of sodium sulphate were added and boiling was resumed for half an hour. This caused the liquid to turn bright red. The solution was cooled, diluted with an equal amount of water and filtered. It was found that in order to destroy the red color due to phenolphthalein, 1.2 cubic centimeters of 1/10-n. hydrochloric acid had to be added for each 200 cubic centimeters of the diluted solution, and to obtain complete neutralization the further addition of methyl orange and 1.6 cubic centimeters of hydrochloric acid was required. It follows that in this boiling experiment about 0.025 gramme of Na_2CO_3 was formed and about 0.034 gramme of Na_2SO_4 was decomposed.—Zeitschrift für angewandte Chemie.

NEW APPLICATION OF MICRO-CULTURE.

It is known that in everything in which vegetable microbes are concerned, a regulation and improvement of production has been attained by "sowing" with selected varieties of microbes. In wine culture and in distilling, the use of yeast prepared in the laboratory is now in very general use; in cheese manufacture, it is maintained, it is possible to produce anywhere, Roquefort for example, by collecting suitable spores in a culture medium similar to that which is employed in the celebrated caves (same composition of the milk, same temperature, same humidity) and is there found to be favorable to its proliferation.

In keeping with this idea, M. J. Crolbois is perfecting a mode of preserving "silo" fodder, according to Cosmos. It is known that fodder which it is wished to use during the winter, and in a fresh state, is preserved in "silos" or ditches in the earth, where it is covered over by an insulating, protective layer of straw or of earth. This is done with sugar pulp, the parings from beet roots, etc., from which sugar is extracted by washing with hot water, and which are produced in the North in millions of kilogrammes and are very advantageously employed in fattening cattle. This fodder undergoes, during the "silo" treatment, an acid fermentation which gives it a taste which is very agreeable to the cattle (although it is objectionable in odor) and facilitates by partial solution the assimilation of the digestive constituents. But the transformation is very slow and irregular, and according to the mode of ensilage, the temperature, quality of the pulp, etc., there are obtained products of a better or a poorer quality.

M. Crolbois conceived the idea of "sowing" the pulp, during ensilage, with a culture of lactic ferments which were accustomed to acid pulps.

One hundred kilogrammes of residue treated in this manner by 6 liters of beet-root juice rich in ferments will be completely and perfectly transformed after forty-eight hours. There is thus, moreover, no necessity for pressing the pulp, which hitherto has been indispensable.

After some trials, the method was applied on a large scale at an agricultural station in the Oise and upon three million kilogrammes of pulp; it yielded no bad-smelling products and hastened the process of fattening the cattle, so that it required three weeks instead of a month.

It has been found possible to feed sheep on this fodder, wherein it differs from the ordinary "silo" pulp.

TELLING TIME BY AUTOMATIC MACHINERY.*

AN IMPORTANT MODERN INDUSTRIAL DEVELOPMENT.

BY SNOWDEN B. REDFIELD.

Every home has at least one piece of more or less high-grade machinery to assist in the proper regulation of household affairs. By this piece of machinery is not meant either the sewing machine or the lawn mower, because these two devices require constant attention during their operation, and the reference is to automatic and semi-automatic machines. The piece of semi-automatic machinery which is common to practically every household is the ordinary domestic clock.

Few people consider the clock as a piece of machinery, especially when gotten up in the cheap forms which are now so universal. It is a fact, however, that the principal clock builders employ skilled engineers, both electrical and mechanical, in the turning out of their products, and some of the automatic clock devices which are becoming more and more commercially popular in the effort to provide uniform standard time throughout the country show in their ingenious make-up the inventive mind of the trained engineer.

ACCURATE OR UNIFORM TIME.

Importance of accuracy of time measurement is well appreciated, but a moment's thought will indicate that the harmonious running of a large establishment such as a manufacturing concern or a school, each with many separate departments, depends more upon uniformity of time in all departments than upon absolute accuracy. If simultaneous actions in different parts of a large establishment are dependent upon the clock, it is necessary that the clocks in all departments shall tell exactly the same time.

Under old-style methods this result could be secured only by using many high-grade clocks, each very expensive and even then liable to vary one from another. The modern way to accomplish this result is to install one high-grade accurate master clock which will automatically regulate any number of secondary clocks throughout the establishment so that they will all exactly agree. This automatic regulation can be extended to include the employees' time recorders in all parts of the plant, the watchmen's time detectors, and even the time stamps in the offices.

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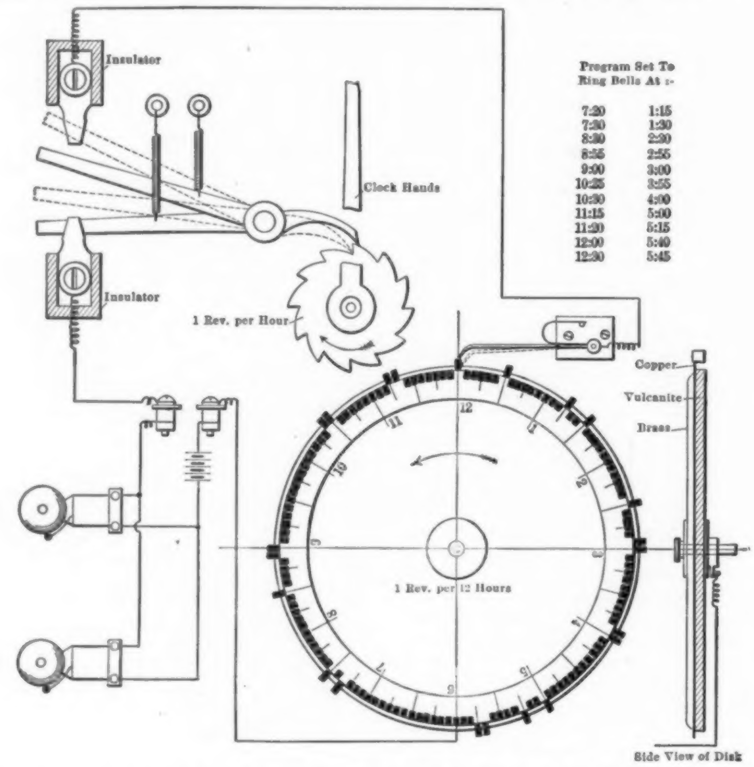


Fig. 2.—DIAGRAM OF SINGLE DISK 12-HOUR PROGRAMME MECHANISM WITH 5-MINUTE TIME UNITS.

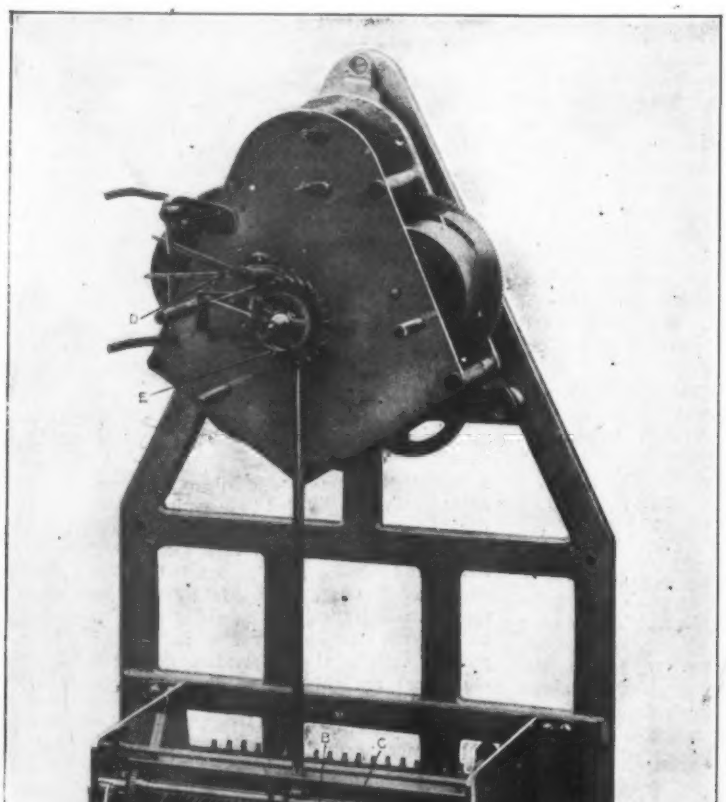


Fig. 1.—PROGRAMME CLOCK MECHANISM.

A, main contact cylinder; B, cam roller to control contact brushes; C, contact brushes; D, scissors switches; E, motion gearing.

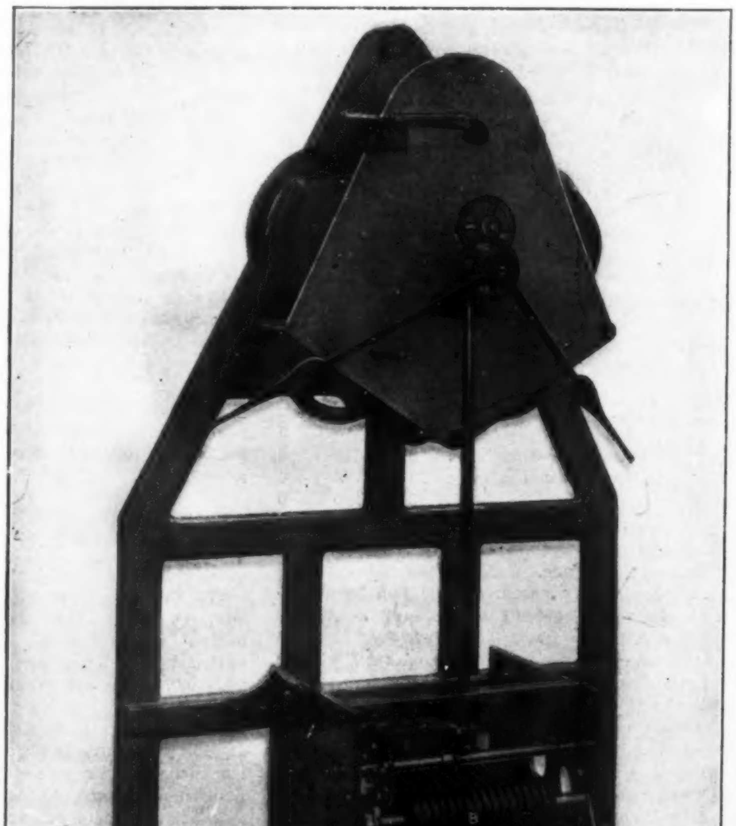


Fig. 3.—ANOTHER PROGRAMME CLOCK.

A, lever to operate B; B, cam roller to control brushes; C, star wheel to skip Saturday and Sunday.

In many of these establishments, especially schools, it is also necessary to ring signal bells at certain intervals for the changing of classes, etc., these programmes often varying for different parts of the day and for different days of the week. The ringing of these bells is accomplished by what is known as a programme clock which may be so arranged as to automatically care for almost any schedule.

One form of secondary clock controlled by a master clock is met with by every traveler, that is, the clocks so often seen in railroad stations which, it is proclaimed, are corrected "hourly." If one happens to glance at one of these clocks on the even hour, he will notice that at this time the hands will suddenly jump and stand rigidly at the hour for a few seconds. These are known as secondary, synchronized clocks, and they are all set or synchronized once an hour by a central master clock of high-grade construction.

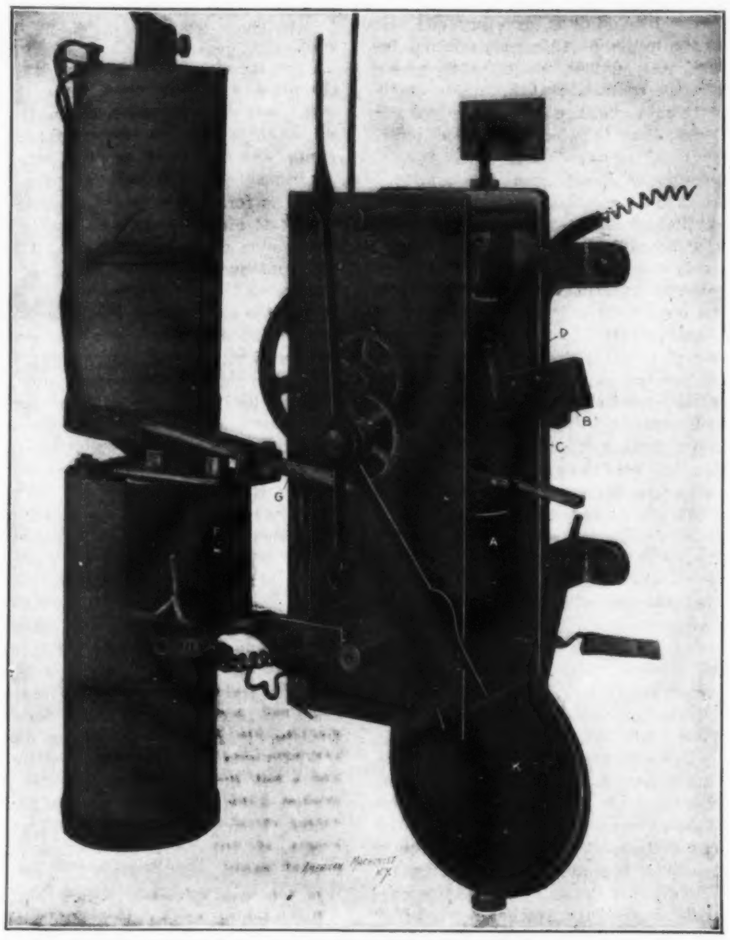


Fig. 4.—SELF-WINDING SYNCHRONIZED SECONDARY CLOCK.

A, electromagnet for lifting B; B, weight to operate clock; C, auxiliary lever; D, knife switch for C; F, electromagnet for synchronizing; G, armature lever carrying synchronizing wedge; H, heart cam. K, clock pendulum; L, winding batteries.

Another common term in the modern clock field is the self-winding clock. These clocks, as the name implies, do not need to be wound by hand, as they receive their energy from electric batteries, or from an electric power line. Master clocks may be either weight or spring operated, or self-winding, and by their high-grade construction they keep accurate time and also synchronize any number of secondary clocks which may be on the same electric circuit with them.

There are three varieties of secondary clocks. The secondary clock may be weight or spring operated and synchronized once an hour by the master clock, or it may be of the self-winding variety, also synchronized once an hour by the master clock. These synchronized secondary clocks are provided either with pendulum or balance wheel. The third style of secondary clock is vulgarly known as the "minute jumper." These latter devices can hardly be classed under the name of clocks at all, for the mechanism inside of the case is extremely limited. In these minute jumpers the hands move only once a minute, and thus the minute hand travels around the hour in sixty evenly-spaced jumps, standing at any one minute stock still until another minute has elapsed. The jumping impulses are all sent out by the master clock and, as said, any number of secondary clocks of this character or, for that matter, of any one of the three types of secondary clocks can be controlled by one master clock.

PROGRAMME CLOCKS—THE BELL RINGERS.

To go into the matter of the programme clock which is so common to any modern school system, an examination of Fig. 1 will reveal the general appearance of the inside workings of such a device manufactured by the Prentiss Clock Improvement Company, of New York city. This clock is usually of the weight- or spring-wound variety, often of the 60-day type, and its function is not only to keep accurate time but also to ring any number of bells according to practically any prearranged time schedule. The programme clock may also at the same time operate any number of secondary clocks either by synchronizing them once an hour or by operating them as minute jumpers. In this way one expensive high-grade central timepiece controls the movements throughout a large school building for changing classes, assigning lessons, beginning recitations, announcing recesses, etc., and, what is clearly seen to be most important, also provides accurate time on the secondary clock in each individual room.

Study of the diagram Fig. 2 will show the operation of the programme system. The cylinder at the bottom, as shown in Fig. 1, is illustrated in the diagram as a circle or disk having a serrated edge. The cylinder is made up of several of these serrated disks,

Fig. 5.—A "MINUTE JUMPER" SECONDARY CLOCK.

A. electromagnet for lifting B; B, weight to operate ratchet and pawl; C, main ratchet wheel; D, non-reverse pawl.

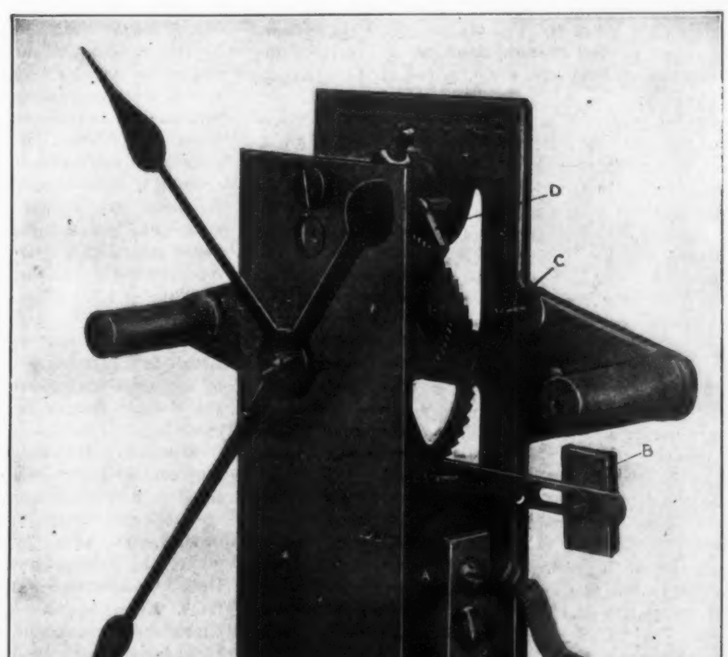


Fig. 6.—A DESCENDANT OF THE "GRANDFATHER CLOCK."

A, actuating wheel; B, auxiliary wheel for skipping the 31st; C, cam for skipping the 30th; D, cam for skipping the 29th of February; E, wheel for adding February 29th in the leap year; F, trigger operated by clock; G, trip moved by teeth of A.

which are made of thin sheet copper, placed side by side on the same axis, but separated from each other by fiber spacers. The length of the cylinder depends upon the number of disks which there are in the arrangement. Resting upon the serrated points of the disks, as shown in the diagram, there are electric contact brushes, and these serrated copper disks are also in electric contact with the shaft of the cylinder and so with the framework of the mechanism. The cylinder is driven by the clock mechanism, the ratio of the gearing being such that one of the serrations or contact points on the disks passes under the brushes every so often, say once in five minutes or once in one minute, depending upon the schedule desired. The brushes bearing upon the little contacts lead to the automatic scissor-shaped switches shown in the upper part of the diagram and also shown in the half-tone, Fig. 1. Farther on, these electric circuits pass through the battery and through the various bells to be rung. These are connected in parallel with each other. If there are many bells they will be rung by a relay which does away with a heavy current in the programme mechanism. Electric condensers are also provided to eliminate sparking and burning of the contacts due to high inductance in a circuit having many bells.

The serrated contact points on the disks being of thin copper are easily bent down sideways so that they will not come in contact with the electric brushes bearing upon the circumference of the disks; and when they are bent down, the brushes rest upon intermediate fiber disks so that no electric contact is made. Only those points left standing will make electric connection with the brushes as the disks turn around. In this way, there being one contact for each unit of time, as selected, by turning down certain contacts and leaving certain others standing up, the electric contact can be made just as often throughout the day and at just as regular or irregular intervals as may be desired.

CUTTING ELECTRIC CURRENTS WITH SCISSORS.

Of course the cylinder turns comparatively slow, and it takes some little time for the contact points to traverse under the contact brushes. This would lead to very slow making and breaking of contacts, causing sparking and burning of the contacts themselves, and also would continue the ringing of bells possibly for five minutes or more. These objections are overcome by the use of the little scissor switch already mentioned. The office of this switch is to make and break the electric circuit with a quick snap and also to cut down the duration of the flow of the current and the continued ringing of the bells. This can be regulated so that the bells will ring for five, ten, or fifteen seconds, as may be desired.

These little switches, as their name implies, are composed of what closely resemble the two blades and handles of a small pair of manicure scissors. When the scissors are open the upper handle makes electric contact with the little knife switch above it, and the lower handle makes another electric contact with a knife switch below it. The blade ends of the scissors are raised up and dropped down by the teeth of the circular-saw-shaped cam which is rotated by the clock mechanism.

One of the little blades of the scissors is shorter than the other by a fractional amount. Consider now that in the diagram of Fig. 2 the circular-saw-shaped cam revolves to the right. This lifts up both of the scissor blades and consequently drops down both of the scissor handles, the handles remaining apart a distance slightly less than the distance between the upper and lower knife switches mounted on the frame. Thus it is seen that, while the blades are rising and the handle descending, no electric contact is yet made. However, when the scissor blades have about reached the top of the saw tooth on the cam, the lower handle does come into electric contact with the lower knife switch, but as the upper handle does not touch the upper switch, still no current flows. The upper handle is the one which is connected to the scissor blade which is slightly shorter than its mate.

As the circular-saw cam continues to revolve to the right, there will come a time when the short scissor blade will slip over the end of the saw tooth, and by the action of the spring this blade drops quickly down and the handle flies up, striking the upper knife switch and completing the electric circuit from one switch to the other through the two scissor handles and their central common pivot.

While the parts are in this position the electric current is flowing and the electric bells throughout the building are all ringing. While this is going on also the circular-saw cam is continuing to revolve in the same direction, and within a very short interval the other scissor blade, which is connected to the lower scissor handle, also slips off the end of the saw tooth, and by the action of a spring the blade flies down and the handle flies up, breaking the electric contact on the lower knife switch. This immediately cuts off the electric current and stops the ringing of the bells.

It is now seen that while the contacts of the serrated points of the main copper disks with the contact brushes bearing upon these points are of considerable duration, the circuit is only completed when the scissor handles are sprung apart, coming into contact with the two knife switches, thus accurately and instantaneously controlling the time of the flow of the electric current. These little scissor switches fly open and shut, making their knife-switch connections every so often, that is, every five minutes, or every one minute, according to the minimum time unit selected, but the bells do not ring unless while these scissor switches are open, the contact brushes bearing on the disk are in actual contact with one of the raised projections on the disk, thus completing the electric circuit.

DIVIDING THE DAY'S WORK.

Why have so many of the little serrated disks side by side on the cylinder? The number of these disks depends upon what schedule it is desired to carry out, and, as a rule, only one of these disks is in electric contact with the circuit at a time, although when there is more than one circuit there is, of course, a set of disks for each circuit, provided the programme is not alike on the several circuits. The cylinder and the disks must revolve at some convenient speed in order to make the contact points of convenient size, and so when the schedule requires frequent signals it has to be divided up into a number of disks, one disk taking care of part of the day, say, three hours, from 12 to 3, the next disk continuing the programme from 3 to 6, and so on throughout the 24 hours.

All the contact brushes connecting with any one bell circuit are hung upon a common shaft at the fulcrum end and are short-circuited on each other, so that some provision must be made allowing only one brush for each circuit to come in contact with its revolving disk at a time. This brush is that which presses upon the disk controlling the programme for that particular portion of the day's operation.

In order to control these contact brushes, a small roller, seen in Figs. 1 and 3, just above the cylinder, comes into play. This roller contains a series of cams, one cam for each contact brush. Under normal conditions the cam lifts up the brush so that it does press against the disk, but there is one cam for each disk which for any one position of the roller will allow the brush over that disk to drop down and rest upon the contact points. Every time the cylinder revolves once a pin on the cylinder moves a ratchet lever which revolves the upper roller a given portion of a revolution, and this revolution of the roller lifts up the brush or brushes which have just been in operation and drops down the next set to bear upon the next following disk to carry on the programme. This continues throughout the day, each brush operating to ring the bells according to the disk upon which it is allowed to rest, depending upon the position of the cams on the upper roller.

SATURDAY AND SUNDAY REST.

In most schools the bells would not be required on Saturdays and Sundays, and during this time the circuit is automatically disconnected from the apparatus by the operation of the small star wheel at the right end of the cylinder. This star wheel has seven points, and as the upper roller revolves once each day it turns this star wheel one-seventh of a revolution. On Saturday the star wheel will have reached such a position that a cam located on its axis will lift up a little lever, opening a knife switch in the main circuit cutting off the bells. On Sunday the knife switch will still be held open, but on Monday morning again by the turning of the star wheel by the roller the circuit is thrown into connection and the programme continued. In boarding schools it is usual that certain bells have to ring on Saturdays and Sundays, but their schedule is, of course, entirely different from the ordinary school day. This latter arrangement is secured simply by having a separate set of contact disks thrown into the electric circuits to carry out the programme for these days.

When the programmes are simple and not more than four contact disks are required, the cylinder is substituted by a short drum which is fastened directly onto the clock mechanism, thus making the apparatus much smaller. The hourly or daily change in the schedule is secured by different disks as before, and they are controlled by a star wheel carrying properly arranged contacts. There is practically no limit to the number of changes of programme which may be provided, and these have been built by the Prentiss company, to include 42 disks, this being necessary for providing a contact for each minute of the day for seven days a week, and operating several separate circuits from the same mechanism.

MASTER AND SYNCHRONIZED SECONDARY CLOCKS.

So much for the programme arrangement. It has been said that an accurate clock may act as a master clock to drive or synchronize any number of secondary clocks. What is the synchronizing mechanism? In the master clock there is provided a little scissor switch already described, this scissor switch operating once an hour. In the secondary clock the hands, while rigidly connected to each other as usual by the "motion gearing," which gives the ratio of 1 to 12 between the hour and minute hands, are mounted upon a friction sleeve sliding over the driving shaft of the clock. By this means the clock may continue to run while it is perfectly possible to change the hands to any position from some external source. This is common to any of the old-fashioned clocks whose setting was accomplished by turning the hands with the fingers.

Upon the sleeve axis of the minute hand of the synchronized secondary clock there is a modified heart cam. Into the depression of the heart when the minute hand is close to the even hour there will fit a wedge which is lifted up by a lever controlled by an electromagnet. With the operation of the magnet the wedge is forced into the depression in the heart cam, and if it strikes anywhere within the curvature on either side of the central line, it will turn the cam and consequently the hands of the clock, to a slight degree, so that the wedge will fit down into the bottom of the depression. When the wedge is in the bottom of the depression, the hands are held rigidly at the even-hour point.

SETTING EVERY HOUR.

Synchronizing is simply that just before the even hour the master clock by means of a scissor switch sends out an electric current from a few cells of dry battery which forces the wedge on each of the secondary clocks in circuit into the depression in the heart cams. All the minute hands of all the secondary clocks then jump to the even-hour point, and are rigidly held in that position. Just at the time when the even hour is passed, the electric contact is broken in the master clock by the scissor switch; all the electromagnets release their grip upon the levers and wedges, which in turn release the heart cams and the hands of the secondary clocks so that the latter continue to travel onward by the ordinary operation of the clock mechanism within themselves, each clock starting the hour at exactly the same instant. This synchronizing will take care of a time variation of one and a half minutes fast or slow, so that even with the crudest kind of secondary clock the electric synchronizing circuit could be out of order for a considerable length of time without becoming ineffectual when started again.

DO NOT NEED WINDING. PERPETUAL MOTION AT LAST?

Self-winding clocks have been mentioned. These may be either master or secondary synchronized. In some forms of self-winding clocks an electric motor is used to wind up a short spring at frequent intervals, this electric motor of course adding to the expense of each self-winding clock, whether it be of the master or secondary type. In the style of clock illustrated in Fig. 4, driving is done by a very small brass weight mounted on the end of a lever. This is seen at the right in the half-tone. The weight bearing the lever down operates a little ratchet and pawl which turns the main wheel of the clock, drives the gearing, operates the pendulum, and turns the hands.

When at the end of about five minutes the little weight has reached the bottom of its travel a secondary lever mounted on the main lever strikes against a pin and is gradually raised up until it forms contact with a small electric knife switch on the main lever. This contact throws an electric current through a pair of electromagnets which draw down an armature. This armature in turn strikes against the opposite end of the weighted lever, thus throwing the lever with considerable force and raising the weight on the driving end. As the weight is thrown upward, the little secondary lever which first made the electric contact strikes against a second pin, and the momentum of the rising weight throws out the little knife switch so as to break the electric contact. The armature then falls away from the electromagnet and the little weight is again allowed to bring all its pressure to bear upon the main driving wheel of the clock, continuing its operation.

The secondary lever to form the electric contact is necessary because if the main lever formed the contact the lever and weight would be jumping up and down continuously like the vibrator on an electric bell. It is necessary, therefore, by means of a secondary lever to have the electric contact continue during the time that the weight is being raised by the electromagnet, and after the raising has been completed the contact is broken as said by the action of the momentum of the rising weight. Electric power to drive these self-winding clocks is furnished by three ordinary dry-battery cells such as are used for ringing an ordinary front-door bell.

This arrangement works nicely for secondary clocks which are synchronized once an hour by a master clock, but it will be realized that if the clock is not being driven during the very short interval while the weight is being raised by the electromagnet, one beat of the pendulum may be lost. If this occurs once in five minutes or once in two and a half minutes throughout the 24 hours, the close regulation of the clock, which regulation is accomplished by the adjustment of the pendulum, is a practical impossibility.

It is possible, however, to use this little weight

mechanism of the self-winding device for driving the master clock with the highest degree of time accuracy, and this device is used for master clocks by the interposition of a small spring link between the driving lever and the main gear wheel of the clock. When the weight is bearing down, the driving force is transmitted perfectly by the spring. Now, when the weight has reached the bottom of its travel and is suddenly lifted up by the electromagnet, the spring between the lever and the main gear wheel will expand so as to continue the pressure of the weight through the spring onto the gear wheel, or rather the spring pushes against the gear wheel so as to assist in the raising of the weight. In this way the actual pressure transmitted to the clock mechanism is practically the same, no matter whether the weight is rising or falling, for the compression and extension of the spring are relatively small. This spring needs no winding; it is simply a flexible link in the power transmission.

TIME GOES BY JUMPS.

Minute jumpers might be characterized as rudimentary clocks. The mechanism of a minute jumper, unlike the self-winding clocks, whether secondary or master, is not provided with any pendulum. Their driving mechanism consists of an electromagnet, which receives an impulse of an electric current from the master clock once a minute by a pair of scissor switches in the master clock.

This electric impulse draws over the armature of an electromagnet, which in turn operates a ratchet and pawl on the main gear of the secondary clock. The drawing over of the magnet armature moves the pawl so as to take another step on the teeth of the ratchet wheel, and at the instant the current is cut off, the pawl lever is operated by a little weight so as to push the ratchet wheel around one notch, corresponding to one minute interval on the minute hand. A second pawl assures that the gear wheel does not turn backward, and furthermore, the forward motion of the driving lever forces its pawl under a stop pin in such a way that while in the forward position the ratchet wheel is absolutely locked against turning farther. This prevents any over-travel of the hands due to their momentum, for the operation of jumping from one minute to the next is quite sudden, and unless the hands were positively stopped on each minute, they might travel around several minutes at a time.

Further provision is also made so that the hands are locked in both directions during the time that the driving mechanism is drawn back and before it is released to be forced forward by the operating weight. This system of three locks effectually prevents the hands from moving except at the proper instant, and then limits their motion to the space of one minute at a jump. No synchronizers are, of course, necessary with these minute jumpers, as they are set once a minute, and the master clock may be either of the spring- or weight-wound, or self-winding type. If the last, it will be provided with the small spring link between the operating weight and the main gear, so as to insure the highest grade of time-keeping.

Minute jumpers have an advantage over a synchronized secondary clock principally where, as in a factory, there might be excessive vibration which would stop a pendulum clock. The minute jumper is also simpler than a set of self-winding synchronized secondaries in that a whole set of the former may be operated by one set of dry cells, none being required for synchronizing.

GRANDFATHER'S CLOCK OUTDONE.

Most of us have seen the celebrated and long familiar "grandfather clock." The majority of these old clocks were provided with a calendar hand which would tell the day of the month. Others also told the day of the week, and still others had a window cut in the upper part of the dial through which could be seen a "humanized" moon face slowly moving across the opening. This was supposed to give the phases of the moon.

In almost every instance if the calendar mechanism was not out of order, the moon mechanism certainly was, and furthermore, the calendar mechanism, nine times out of ten, was of the slow-moving variety, so that in the evening it was almost impossible to tell whether the date was the 25th or 26th, because the hand was very nearly half way between. It is, however, probable that in the old days when our great-grandfathers used to go to bed early they had no occasion to look at the clock when the calendar hand was half way between the date numbers, so that they were never troubled by this paradoxical state of affairs.

In these old devices, moreover, the calendar mechanism included 31 days in the month, and if the month had only 30 days, or if it was February, with 28 days, it was necessary for the master of the house to be particular at the first of each month to set the calendar hand, so as to give the correct date.

Since the times of our great-grandfathers, with their characteristic style of clock, there have been many improvements made in clock-operated mechanisms. Fig. 6 is an illustration of such a mechanism, a clock calendar which, it is claimed, is quite a popular article. The ingenious feature of this calendar clock is that not only does the mechanism automatically take care of months having 31 days and 30 days, but also cuts down the length of the month to 28 days for each February.

NO FEAR OF LEAP YEAR.

Aside from this, this apparatus is provided with a mechanism which, every four years, will automatically add another day to the February calendar, giving it the 29 days required by leap year. Furthermore, this mechanism need be wound only once a year, this operation being performed presumably at the time when New Year's resolutions are recorded. It is not stated that there is any automatic mechanism provided for the insurance of the carrying out of these New Year resolutions. This feature seems to be lacking.

When the calendar mechanism, illustrated in Fig. 6, is placed inside the clock case, it is, of course, possible to see only one date at a time; that is, one day of the week, one month, and one day of the month. The movements of the various names and figures are intermittent, so that the calendar moves only at midnight. All the rest of the time the names and figures stare steadily out of the windows in the clock case, so that there need be no uncertainty about knowing the exact date, no matter how late one may sit up at night.

Driving of this apparatus is accomplished by a spring in the bottom entirely independent of the clock spring. The release mechanism, however, is controlled by the clock, which at midnight presses down on the lever stretching over the top of the mechanism which sets the apparatus in motion.

Moving of the calendar mechanism is produced by the large wheel at the bottom. This wheel, as seen, is provided with 31 ratchet teeth in its periphery; that is, one for each day of the month. There is also one other tooth space left blank. The blank one is necessary because while there are only 31 dates, there is room on the date cards for 32 dates, as there is a date on each side of the card. By this arrangement, the cards turning over once a revolution and using both faces, 16 cards will do for a whole month, instead of using 31 cards, thus greatly simplifying the mechanism.

On the side of the main ratchet wheel will be seen smaller auxiliary ratchet wheels. One of these is centered on one of the spokes of the main wheel between the hub and the rim. In a similar position on the first small auxiliary ratchet wheel there is a second wheel which is centered on the face of the first auxiliary wheel. In the rim of the first auxiliary wheel there are depressed and raised sections which by the motion of the large wheel are moved into position, one section for each revolution of the large wheel. The ratchet teeth in the large wheel are for the turning of the days of the month, one day for each tooth. The days of the week of course turn one after the other throughout the year, and the months are changed one month for each revolution of the large wheel.

The object of the small auxiliary ratchet wheels is to alter the number of teeth in the large wheel to correspond to the number of days in the month. When there are 31 days in the months, the 31 teeth in the large wheel are not interfered with by the auxiliary wheels, so that the day of the month mechanism is operated 31 times for that month. The 32nd space being blank does not affect the date. For a 30-day month, it is so arranged that by the motion of the first auxiliary wheel a raised section is moved to fill up one tooth space of the main wheel so that the mechanism slides over this tooth, skipping the 31st of the month and turning the calendar to the first.

In February the auxiliary wheel is so turned that it automatically raises two small lever cams to fill up the spaces in the large wheel corresponding to both the 29th and the 30th of the month. The tripping mechanism slides over the 29th, 30th and 31st of the month, and skips from the 28th of February to the 1st of March in ordinary years. Now, however, when a leap year comes around, it will be found that the second auxiliary wheel has pulled out a small pin which allows one of these lever cams to drop down, opening up the space in the rim of the main wheel corresponding to the 29th of the month, so that the mechanism will operate for the 28th and the 29th, then skipping the 30th and 31st and turning to the 1st of March.

No provision is made for skipping this day once in 400 years, when leap year is omitted, but it is not probable, judging from our "grandfather clock" records that the apparatus will last that long under ordinary conditions. This feature, therefore, will hardly be missed.

TAKING FATHER'S WATCH APART.

With this clock calendar there is given a circular describing the method of setting, but as one can discover only once in four years whether or not the calendar is correctly set, it is well worth while not to trifle with it after it comes from the hands of the expert. The fact is, however, that the mechanically inclined person has hard work to keep his hands off such a device as this until he has learned to respect it.

It is said also that in the case of the programme clock, especially in the high schools where there is usually a physics professor, this latter gentleman is found to be especially anxious to discover how these mechanisms work. To guard against the depredations of these investigative temperaments, it has been suggested that a small placard be put inside of each clock reading as follows: "Ordinary people will not, and physics professors must not, attempt to find out how these clocks work by taking them apart."

NOMENCLATURE OF THE CONSTITUENTS OF STEEL.

THE International Association for Testing Materials having taken into consideration the report handed in by Messrs. H. Howe and A. Sauveur in regard to the uniform nomenclature of iron and steel, and Mr. E. Heyn's report on the progress made in metallography, Mr. H. Le Chatelier recommended at the recent Copenhagen Congress the adoption of certain definitions, with a view to render the list of the constituents of steel both more precise and more simple. According to the method proposed, the microscopical constituents of steel are divided into chemically homogeneous constituents, "metaral," and into chemically heterogeneous constituents, "aggregat." These microscopical constituents, classified in the order of their increasing complication, are as follows: (1) Ferrite, α iron, containing in solution, in commercial iron and steels, very low percentages of the other elements, and containing always less than 0.05 of carbon. (2) Graphite, a variety of carbon which is identical with the graphite of mineralogists, characterized by a density of 2.25, and capable of yielding graphite oxide under the action of suitable oxidizing agents. (3) Cementite, a carbide of iron represented by Fe_3C. (4) Austenite, a solid solution of carbon and iron in the γ state, normally stable above the zone of the critical temperatures for steel. In some special cases this state may exist at ordinary temperatures, and the steel is then characterized by the low degree of magnetic permeability (ferro-nickel, manganese steel). These four constituents are chemically homogeneous. (5) Pearlite, an "aggregat" constituted by the eutectoid proceeding from the normal separation into ferrite and cementite of the austenite cooled down slowly below the zone of the critical temperatures for steels. It contains on an average approximately 0.9 per cent of carbon. (6) Martensite, a "metaral," a solid solution of carbon and iron. At no temperature is this normally stable, and it can be maintained in a metastable phase only at low temperatures. With a similar composition, it is distinguished from austenite by its magnetic permeability and its greater hardness. It is obtained by cooling down steel, from temperatures above that of the critical zone, rapidly enough to prevent the splitting up of the austenite with a consequent production of pearlite, but at the same time slowly enough to maintain the austenite unaltered. Characteristic specimens of martensite are obtained by quenching in cold water from 800 deg. C. (1,472 deg. F.) bars 1 centimeter square of eutectoid steel; i. e., steel containing about 0.9 per cent of carbon. (7) Osmondite, the homogeneity or heterogeneity of which is still under discussion, marks an intermediate stage in the return of martensite to the pearlite phases. It is more stable than martensite at ordinary temperatures. It is considered to be a constituent proper owing to the existence of a discontinuity in the variation of certain properties of the metal during transformation from one extreme phase to the other. It is characterized by a maximum solubility in acids, and by a maximum coloration by the action of acid metallographical reagents. It can be obtained very definitely by annealing at 400 deg. C. (752 deg. F.) the martensite of eutectoid steel; i. e., steel containing about 0.9 per cent carbon.—Engineering.

The first monochromatic pictures of the sun, with the dark rays of the spectrum, were obtained in 1894 by Deslandres, who called attention at the same time to the great extension which is possible for this new application to spectroheliography. These pictures disclosed, over the entire disk, the distribution and the intensity of the vaporous atmosphere which produces the dark rays by absorption, and since the dark rays numbered 20,000, and since each of them is able, *à priori*, to give a different picture, the new field open to the investigation of astronomers is announced as extremely large. Studying these lines with the large spectroheliograph with three slits, Messrs. H. Deslandres and L. d'Azambuja have been able to identify the successive strata of iron, of calcium, and of hydrogen, and particularly the superincumbent strata, which are the more difficult to distinguish, but at the same time more interesting.

A NEW SWISS MOUNTAIN ROAD.

MARTIGNY-CHATELARD LINE.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

A NEW electric mountain railroad has been opened in Switzerland, which on account of the picturesque character of the region it traverses is one of the most interesting for tourists. The new railroad lies in the Mont Blanc region, and it gives a passage through the valley at the base of the mountain range, which was lacking heretofore. Chamonix could already be reached by the electric line which the Paris-Lyons-Mediterranean Railroad Company constructed some years ago, and this new line already opened the Mont Blanc region, having Chamonix as a center. Before this the region could be reached only on foot or by diligence. An electric line was needed to take tourists beyond Chamonix and along the mountain through the wild and picturesque valley of the Trient, descending thence into the valley of the Rhone, which lies on the other side. In this way tourists are not only able to enjoy the views over this part of the Mont Blanc region, but they also make connection in the Rhone valley with the Swiss Federal Railroad, which runs from Lake Leman as far as the Simplon tunnel. They have thus the choice of taking the train for the Simplon and proceeding through the tunnel into Italy, or on the other hand of reaching the shore of Lake Leman and returning to Geneva by the railroad running along the south shore of the lake, or else of passing by the east end of the lake to Lausanne and thence to the northern part of Switzerland.

In order to carry out this plan, the Paris-Lyons-Mediterranean company extended their line from Chamonix as far as the Swiss frontier at Chatelard, for it will be remembered Chamonix lies in French territory. We then make connection at the frontier with the new Swiss electric line which runs thence to the Rhone valley and reaches the railroad station of Martigny on the Federal line. The two electric lines united make a continuous trip from Fayet, which we reach from Geneva, by Chamonix and to the Rhone valley, but in reality the new line on Swiss territory is constructed in a different manner as regards many of the leading points, and it was built by a Swiss company, the Martigny-Chatelard Railroad Company. We present some of the views which were taken in the various points along the Trient valley, and these will show that the character of the region is likely to make the electric line well patronized by tourists, who are no longer obliged to end their trip at Chamonix, but will thus greatly extend their course through the Mont Blanc region.

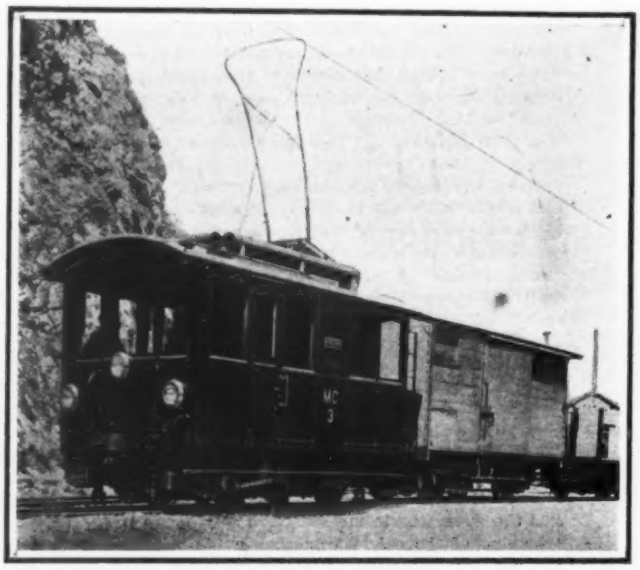
The construction of the new line shows some points which differ from the usual practice in electric mountain railroads, and we have a principal difficulty to be overcome from the fact that owing to the steep grade on one portion, the line is built partly on the rack-rail system and partly on adherence. The electric locomotives and motor cars, both of which are used, had therefore to be designed so as to run on both kinds of track indifferently. The Martigny-Chatelard company, of which M. Loew is chief engineer, designed some forms of locomotive and cars in order to meet these requirements. Especially as concerns the motor cars, seeing that the operation of the combined system is somewhat of an experiment, there were several types made in order to find which proved to be the best.

The electric line from Martigny in the Rhone valley to Chatelard, where it connects with the Chamonix line, is built on a 1-meter (39.37 inches) gage. In spite of the disadvantages we have in a rack-rail system it was decided to use this on the part which proceeds up the side of the mountain so as to reach the Trient valley, as the grade is very steep and the cost would be too high for any other method. The line starts, therefore, from the railroad station of Martigny and runs along the Rhone valley for 2.2 miles on a level grade as far as Vernayaz, at the foot of the mountain. Here begins the rack-rail section, which has a length of 9,494 feet, most of this being on a 20 per cent gradient. On this part there are four masonry bridges and viaducts and three tunnels. From Pontet, at the upper end of the rack-rail, the line runs along the side of the mountain above the Trient valley and has grades of 7 per cent, using ordinary track. It mounts up continually as far as Finhaut (altitude 4,050 feet) and then descends to the terminal point at the French frontier. At one point on the line, it crosses the gorge of the Triege on a handsome viaduct which is represented in one of our views, lying in a wild and picturesque site. In this part we have three bridges over the gorge. At the top is the electric railroad viaduct, which lies high above the other two stone bridges used for the roadway. Another view shows the construction of the railroad viaduct, which has a main arch of 116 feet. The new electric locomotive, which we represent coupled to a freight train, is of a short type with two axles. It is designed to run on the rack rail by means of two pinions driven each by an electric motor, and also to run over the ordinary rail portion, so that the axles are also driven by the same motors. These locomotives are designed to take a train of 17 tons on adherence or a 22-ton train on the rack-rail section, using a speed of 8 miles an hour in the former case and 4.2 miles in the latter. The locomotive measures 15 feet 2 inches between buffers, and weighs 22 tons. It carries two upper axles, each of which is driven by a 150-horse-power electric motor, besides the axles for the running wheels. Each of the upper axles lying next the motor is driven from the latter by a double reduction gearing placed near the end, while at the middle of the axle is mounted the rack wheel, carrying on each side a drum for the brake shoes. From the same axle the running axle of the locomotive is driven by means of cranks and driving bar which are observed on the outer side. The same disposition is used on the other side for the rear axle, and thus each of the electric motors drives first the pinion axle and thence a main axle of the car, so as to give a combined rack and adhesion system. At each end of the locomotive is a grip which runs along under the head of the rack rail so as to prevent the locomotive from lifting off the track. Unlike most electric locomotives, the motors are of the dynamo type and mounted upright on the floor inside the locomotive. The motor is first geared to a countershaft lying at the floor level, and this latter is geared to the axle of the rack wheel. Locomotives somewhat resembling this type are already used in the Swiss mountain lines on the Bex-Gryon-Villars and the Aigle-Leysin roads. Current is taken from the overhead line by means of a bow trolley of the usual kind, or else from the third rail by four contact shoes. To increase the efficacy of the brakes, there is used an automatic device which works on the rack section, and it comes into play at an excessive speed, operating a band brake on the motors.

We also show a view of the type of motor car which uses four motors, and here it is coupled to one of the trailers. These cars are designed to run on the rack rail and also on adherence, and have some novel points. They are designed to take a 17-ton load at 3 miles an hour in the first case and 10 miles in the second, and have central passage with first and second-class compartments, with 52 places in all. The cars are mounted on double bogies of somewhat unusual construction, seeing that the motor lies on the outer side of the axle at each end, instead of on the inner side, as we usually find it. The motor in each case is geared to a countershaft, and this in turn drives the rack wheel which is mounted loose on the running axle of the car. By a second gear set the countershaft drives the wheel shaft, and the speeds are properly adjusted. Each of the four motors gives 60 horse-power.

The second type of motor car is designed to run only on the adherence section at 7 per cent grades, and on the rack section it is drawn or pushed by the locomotive. The car takes off some of the load here by working on adherence at the same time. An unusual point is that the two axles of a bogie are coupled together by crank and bar, and there is but one 75-horse-power motor for driving the outer axle. The inner axles carry a toothed wheel with double brake drum for working on the rack section, but for braking purposes only, as the toothed wheel runs loose on the axle.

TUNNEL ON MARTIGNY-CHATELARD LINE.



ELECTRIC FREIGHT LOCOMOTIVE.

BUILDING THE RACK-RAIL SECTION.

A NEW SWISS MOUNTAIN ROAD.

THEORIES OF BALL LIGHTNING.

ARAGO recognized three varieties of lightning:

1. Ordinary lightning, consisting of one or more fine lines of light, usually zigzag and very bright.

2. Sheet lightning, without definite lines, but extending, with moderate brightness, over large cloud surfaces.

3. Ball lightning.

In 1857 Du Moncel added a fourth variety:

4. Point lightning, consisting of a row of separate points of light. Planté called it bead lightning and asserted that the beads are sometimes connected by a fine line of light.

Two additional forms are now recognized:

5. Ribbon lightning, a luminous band of appreciable

width, resembling a folded ribbon, striped longitudinally and transversely.

6. Brush lightning, which rises slowly from a cloud like certain varieties of fireworks.

This classification does not exhaust all the varieties of lightning which have been observed and which appear to be connected by insensible gradations. Globe lightning, in particular, is certainly related, on one hand, to ordinary lightning, and, on the other hand, to the diverse forms which are grouped under the designation of St. Elmo's fire.

Seneca, in ancient times, asserted that the luminous bodies of ball lightning contain compressed air. Faraday denied the existence of ball lightning, and many other physicists have regarded most of the observed phenomena as subjective, and due to the effect of the intense light of lightning upon the retina.

Two classes of theories, chemical and physical, have been advanced to explain ball lightning. The chemical theories are the older. Muschenbrock, in 1769, regarded ball lightning as an agglomeration of inflammable substances which, after rising from the earth as vapors, condense in the upper atmosphere, and in some way become ignited as they fall. In 1886 Pfeil attempted to revive this theory, and asserted that ball lightning has very little connection with ordinary lightning. Arago conjectured that globe lightning is an agglomeration of ponderable matter strongly impregnated with the matter of lightning. Besnon, in 1852, attributed ball lightning to an accumulation of nitrogen iodide. According to De la Rive and Hildenbrandsson, ball lightning consists of mixed hydrogen and oxygen produced by the electrolysis of water. This theory accounts for the explosion which often terminates the phenomenon. Raasche regards ball lightning as an incandescent mass of gas evolved by electric discharge.

The researches of Tait, Cecil, Calland, Faye, and others have led to the enunciation of several physical theories of ball lightning. Suchsland, for example, regards a thunder cloud as an electric battery of an immense number of cells, each composed of a drop of rain and the oxygen and nitrogen of the atmosphere, and asserts that ball lightning consists of detached cells of this character. Other physical theories have been founded on attempts to reproduce the phenomena of ball lightning in the laboratory. The most important of these experiments were made by Planté and have been repeated and extended by other physicists, including Toepler, who made a systematic study of electric discharges in free air and discovered a form intermediate between the ordinary brush discharge and the voltaic arc, to which he gave the name of brush arc. On these experiments Toepler based a theory, already vaguely foreshadowed by Du Moncel and Planté, which regards globe lightning as a variety of brush discharge. Although Toepler's theory leaves numerous phenomena unexplained, it appears to contain the germ of the complete explanation of globe lightning. Prof. Trowbridge in this country has also experimentally studied the subject, and the results of his researches have been published in these columns.

WASHING CIDER APPLES WITH AN OXIDIZING CALCIUM COMPOUND.

IN the manufacture of cider, washing of the apples is indispensable, in order to get rid of the impurities with which they are contaminated, but it is necessary to take into consideration the defective quality of the water which is available, or which is often used without any discretion.

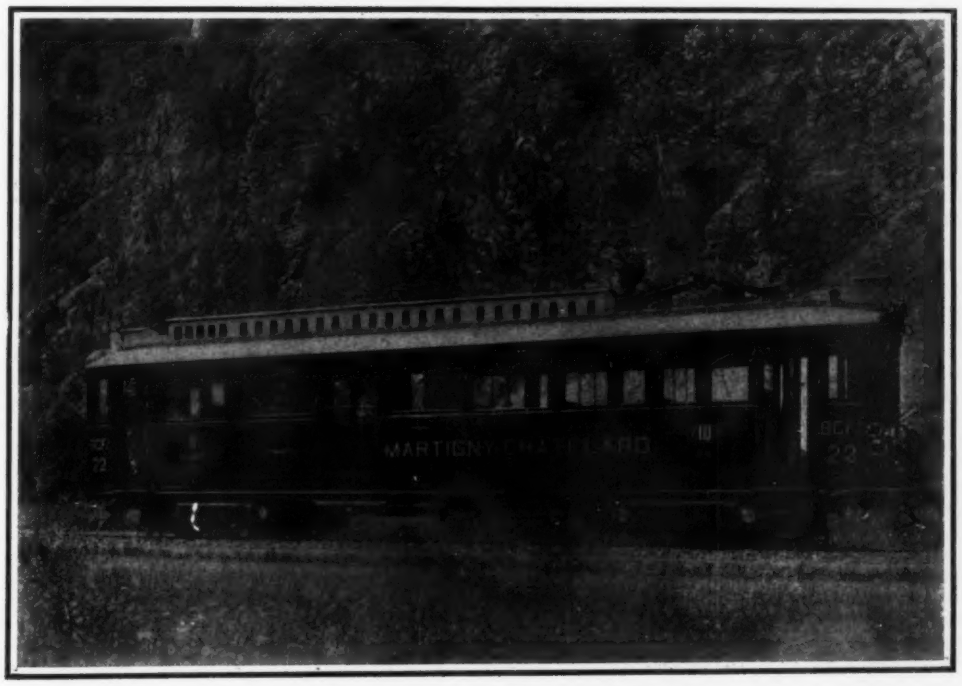
Messrs. Henri Alliot and Gilbert Gimel observed that the addition of hypochlorite of lime (in the proportion of 40 to 60 grammes per hectoliter of water, according to the condition of cleanliness of the fruit) assures, in washing cider apples, the purification of water which is questionable from a bacteriological point of view.

The juices of fruits thus treated undergo an energetic defecation, and are rapidly clarified. The coagulation of the pectic matter is always complete, and there is always a formation of an abundant "head." There is thus assured the stability of the cider for the season. The diastases, notably the maloxydase, being eliminated by the precipitation, one thus avoids the principal cause of darkening of cider.

The hypochloride of lime gives an elective action, favorable on the *Saccharomyces mali*, but noxious as regards the anaerobia. It solves practically and in a simple manner the problem of pure fermentation.

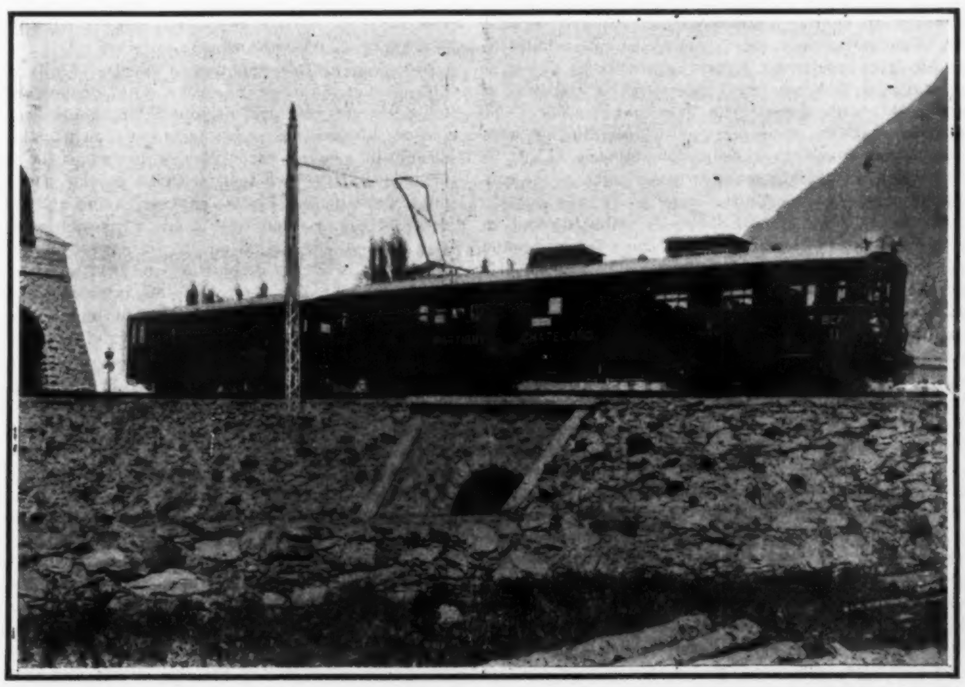
By accompanying this method with repeated decantations, cider is obtained which may be kept for a long time.—Cosmos.

BUILDING THE TRIEGE VIADUCT.



ADHESION MOTOR CAR ONLY.

TRIEGE VIADUCT AND TWO BRIDGES.



MOTOR CAR BUILT FOR ADHESION AND RACK-RAIL.

A NEW SWISS MOUNTAIN ROAD

GASOLINE AND ALCOHOL ENGINES.*

COMMERCIAL DEDUCTIONS FROM COMPARISON TESTS.

BY ROBERT M. STRONG.

INTRODUCTION.

The following report is a summary of the commercial results which were obtained from 2,000 tests conducted by the United States Geological Survey at St. Louis, Mo., and Norfolk, Va., in 1907 and 1908, under the technical supervision of R. H. Fernald, engineer in charge of the producer-gas section of the technologic branch. The tests dealt primarily with gasoline, forming part of the investigation of mineral fuels provided for by acts of Congress. To determine the relative economy and efficiency of gasoline it was compared with denatured alcohol. The tests, many of which were undertaken in connection with work for the Navy Department, supplemented, to a certain extent, the work of previous investigations, but only so far as was necessary to emphasize some of the more important points and to lead up to the defining of conditions required for the economical use of gasoline and alcohol.

In order to determine and eliminate the affecting engine conditions as far as possible, the investigation was commenced by making comparative gasoline and alcohol tests on the same engines. These tests were repeated on other engines of approximately the same size and speed, having different degrees of compression, different methods of governing, and different carbureters. The final report will include much material that may be of use in engine design, but that side of the investigation was not pursued any further than was necessary to obtain the best possible results for alcohol and for gasoline with the engines at hand, and to prove that the minimum fuel-consumption rate for each could be obtained in approximately the same manner. The effects of engine and of operating conditions both have a bearing on the commercial deductions but will be discussed only in a general way at this time.

DIFFERENCES IN ENGINES.

General Statement.—Gasoline and alcohol engines are built and operated on exactly the same principles, and the action of the two fuels is relatively the same. Explosive mixtures of the vapors of gasoline and of alcohol with air are formed in the same manner, and the subsequent burning of these explosive mixtures in the engine cylinder takes place in a similar way and with similar results.

Gasoline Engines Run with Alcohol.—Almost any gasoline engine with a well-designed carbureter will run as well with alcohol as with gasoline, from the standpoint of operation, except for a difference in ease of starting and in certainty of operation at low speeds. Under conditions requiring widely varying speeds the engine is less certain to operate satisfactorily at very low speed when alcohol is used, unless some special adjustment is made. The only change required for the use of alcohol in a gasoline engine, if any, is in the size of the fuel passageways. The fuel needle valve must be capable of being opened twice as wide for alcohol as is required for gasoline, and the spray nozzle must not be restricted to just the size that is required to supply the needed quantity of gasoline. The fuel passageways in a carbureter can usually be easily drilled out, and so far as producing power at constant speed is concerned the engine will be just as serviceable with either fuel. This change need not be such as to affect the consumption of gasoline, but with this change alone the consumption of alcohol will be from one and a half times to twice as much as the consumption of gasoline for the same power.

Special Engines for Alcohol.—By using alcohol in an alcohol engine with a high degree of compression (about 180 pounds per square inch above atmospheric pressure—much higher than can be used for gasoline on account of preignition from the high temperatures produced by compression), the fuel-consumption rate in gallons per horse-power per hour can be reduced to practically the same as the rate of consumption of gasoline for a gasoline engine of the same size and speed. The indications are that this possible 1 to 1 fuel-consumption ratio by volume for gasoline and alcohol engines will hold true for any size or speed, if the cylinder dimensions and revolutions per minute of the two engines are the same.

An alcohol engine is as adaptable to commercial requirements as a gasoline engine, except that with the present types of carbureters the same increased difficulty in starting and in operating at very low speeds is experienced as for a gasoline engine when alcohol fuel is used. The adaptability of alcohol is such, however, that this difference, which is due to ineffective vaporization, is not necessarily permanent.

When alcohol is used in a gasoline engine with the maximum degree of compression for gasoline, the available horse-power of the engine is increased about 10 per cent. An alcohol engine with the maximum degree of compression for alcohol will have an available horse-power 30 per cent greater than a gasoline engine of the same cylinder size, stroke, and speed. Owing to the higher explosion pressures, however, an alcohol engine should be built heavier than a gasoline engine, but the weight per horse-power may be less.

Alteration of Gasoline Engines.—Some gasoline engines may be so changed that a sufficiently high compression pressure is secured to make it possible to reduce the consumption of alcohol in gallons per horse-power per hour to an equality with that for gasoline before the engine was changed; the change, however, precludes the further use of gasoline, as it can not be used satisfactorily with compression pressures much in excess of 70 to 75 pounds per square inch above atmospheric.

The degree of compression may be most easily changed by lengthening the connecting-rod, which changes the position of the piston at the extreme end of the compression stroke. This can be done, however, in an engine which is not counterbored and in which the shape of the clearance space is such that the piston will not strike the cylinder head or valves. The type of connecting rod usually used for stationary engines can be lengthened very easily by putting liners between the crank-pin end of the connecting rod and the crank brasses. This makes it possible to adjust the degree of compression to whatever fuel it is desired to use with but little trouble.

If the cylinder is counterbored, or if there is not sufficient room at the head of the cylinder to allow the piston to travel back far enough to increase the compression pressure to the amount desired, a new cylinder head should be cast with smaller clearance space. Attaching plates to the piston or cylinder head is seldom, if ever, satisfactory. The arrangement of the valve-actuating mechanism often determines the position of the valves, which may be such that a small enough clearance space cannot be secured without almost an entire redesign of the engine. Furthermore, with the increased compression pressure required for the economical use of alcohol, the maximum pressure from explosions or combustion will increase and will be as high as 600 or 700 pounds per square inch for maximum load when the compression is raised to 180 or 200 pounds per square inch above atmospheric pressure. The ordinary stationary engine, especially the horizontal type, is not usually built heavy enough to withstand such pressure continuously; hence, while it may be quite possible to raise the compression of a gasoline engine sufficiently to convert it into an economical alcohol engine, it is not always advisable to do so. This is especially true if the difference in cost of fuel is a comparatively small consideration, as is often the case.

EFFECTS OF FUEL QUALITY.

Mixtures of Gasoline and Alcohol.—The increased difficulty of starting an engine with alcohol and the increased uncertainty of operation under variable speed conditions has suggested the use of gasoline and alcohol in a double carbureter, which mixes the vapors or sprays of the two fuels with air in the usual manner. Tests on two similar engines having different degrees of compression were made with such mixtures. For the two engines 26 and 21 tests were required to obtain the best time of ignition and best mixture quality (as regulated by the fuel needle valve and auxiliary air valve) for 7 different proportions of gasoline and alcohol. The results obtained are not as conclusive for the tests with the higher degree of compression as might be wished on account of affecting engine conditions which were known and recorded but not eliminated. The results of these tests, which will be given in full in the final report, indicate, if rightly interpreted, that the maximum thermal efficiency for mixtures of gasoline and alcohol will vary from that for alcohol alone to that for gasoline alone, when the best degree of compression is used in each case; and that the total fuel consumption will not be less than the minimum for either fuel alone and will depend on the limiting degree of compression for each different proportion. If this be true, there is no advantage in using gasoline and alcohol together except for starting and operating under conditions of variable speed; and these advantages should be obtainable through some other means, such as more suitable design of induction passageways and carbureter. Moreover, the use of gasoline in any appreciable quantity does away with many of the advantages that are obtained from the use of alcohol alone, such as safety and absence of disagreeable odors.

Gasoline with a Spray or Jet of Water.—The fact that the limiting compression pressure for gasoline and alcohol used together was always greater than for gasoline alone suggested that possibly by substituting water for alcohol and so increasing the limit of compression a corresponding increase in thermal efficiency for gasoline could be obtained. Following this suggestion, tests were first made on a gasoline engine with various proportions of gasoline and water. So far as possible the best results were obtained for each given proportion, from all gasoline to as much water as gasoline, but no change in the thermal efficiency or rate of consumption of gasoline could be made; this result showing that the effect of the water, if any, was balanced. Since higher compressions could be used, depending on the proportion of water, a similar set of experiments was made with one of the alcohol engines in which the compression pressure was about 130 pounds per square inch. Again the thermal efficiency could not be increased or the consumption rate decreased to values better than the best obtained for gasoline alone in a gasoline engine. For the two engines 28 and 23 tests were required to determine the best possible results for each percentage of water used; but the results are not conclusive, for there is a question whether the particular engine used for the latter tests, with the higher degree of compression, was free from conditions of construction that affected the best results obtainable. Details of these tests, which have been worked up in full, are to be given in the final report and will afford much information to anyone interested in carrying the investigation further.

In general, the introduction of a small quantity of water with the fuel will prevent preignition from too high compression or overheated parts in the clearance space. The heavy explosion pound often obtained in a gasoline engine operating under maximum load may be entirely eliminated and the running of the engine made much quieter and smoother by using a small quantity of water. The shock and wear of moving parts is thus obviously reduced. If the water contains any grit, however, the cylinder and piston will soon become scored; hence ordinarily it is not advisable to use a spray of water continuously with the air or fuel. The amount of cooling water required to keep the cylinder walls at a given temperature is diminished very noticeably when as much water as gasoline is taken into the cylinder, and the effect of smaller quantities of water is proportional.

Alcohol of Different Strengths.—We are not limited to the use of denatured alcohol, which is about 90 per cent ethyl alcohol, so far as the engine is concerned. Even 50 per cent alcohol can be used, though not very satisfactorily. With this grade an engine is hard to start and is uncertain in operation; that is, the operating conditions are limited. The thermal efficiency decreases rapidly with increased dilution. The rate of decrease of the thermal efficiency with decrease in percentage of alcohol, however, is not constant, but is more and more rapid as the alcohol becomes more dilute. From 94 per cent to 80 per cent alcohol, however, the consumption of pure alcohol is about the same, and the total consumption is almost directly proportional to the increase in percentage of water.

The maximum power of the engine also decreases as the alcohol is diluted, but, as is the case with the thermal efficiency, the percentage of decrease with dilutions between 94 and 80 per cent is negligible. When 50 per cent alcohol is used, however, the maximum horse-power of the engine is only 72 per cent of that for 94 per cent alcohol. Less cooling water is required for the engine cylinders with alcohol than with gasoline, and when the alcohol is diluted with water a further reduction is made in the required quantity of cooling water, the effect being similar to that produced when water spray is taken into the cylinder with the mixture of gasoline vapors and air. When 50 per cent alcohol is used, scarcely any cooling water is required.

Full details of the tests from which the above results were obtained are to be given in the final report. Some of the data are very interesting, including indicator diagrams from two sets of experiments with different carbureters. One set of 15 tests was made with a double carbureter, with which the sprays of water and alcohol were mixed. For the other set of 31 tests previously diluted alcohol was used in a special carbureter. The best results for 5 and 6 different per-

* Bulletin published by United States Geological Survey.

centages of dilution, respectively, were determined. These tests were made on a gasoline engine with a considerably lower degree of compression than that found best for 94 per cent alcohol. No attempts to use higher degrees of compression for the more dilute alcohol were made. The results are conclusive as far as they go. They probably would not be different had a higher degree of compression been used; but, be that as it may, the commercial significance of the results as obtained lies in the fact that if 80 per cent alcohol can be manufactured for 15 per cent less per gallon than 90 per cent alcohol it becomes a commercial advantage to use the lower grade, provided the difference in cost of handling the greater bulk does not offset the gain in cost of manufacture. It is even possible that the use of 70 per cent alcohol or lower grades will prove to be cheaper; but the use of these more dilute alcohols is limited to a certain extent by the difficulty of starting an engine using them and by the increased uncertainty of operation, especially under conditions of variable speed. Adaptability must be taken into account when comparing fuels.

Relative Adaptability of Gasoline and Alcohol.—Different properties limit the availability or determine the adaptability of liquid gasoline and alcohol and their combinations for use in internal-combustion engines of existing types. Gasoline is more volatile than alcohol, and the heat of combustion of a pound of gasoline is considerably greater than that of a pound of alcohol. The weight of air theoretically necessary for complete combustion of a pound of gasoline is different from that for alcohol, but the theoretical heating values of a cubic foot of gasoline vapor and air and a cubic foot of alcohol vapor and air, with just sufficient air for complete combustion in each case, is very nearly the same—about 80 British thermal units. Further than this but little is positively known about the properties of the working mixtures of alcohol or gasoline vapors and air, except that the pressure to which differently proportioned explosive mixtures of air and vapors of either fuel can be compressed without preigniting in the engine varies, and that an explosive mixture of alcohol vapor and air can be compressed to over twice as high a pressure as an explosive mixture of gasoline and air before self-igniting (preigniting in the engine).

Mixtures of air and fuel vapors, or sprayed fuel, are delivered to the cylinder of an engine, mixed with the remaining hot products of combustion, and subsequently burned. Differences in the homogeneity and intimacy of this ultimate mixture, in the limit of excess of air that can be used without the mixture becoming too dilute to fire and in the rate of flame propagation, may each affect the completeness of combustion, and though the mixture quality be relatively the same, alcohol may burn more completely than gasoline, or *vice versa*. The specific heat of the burned or burning charge may also be different for alcohol and for gasoline mixtures, thus changing the theoretical basis of comparison, and may also affect the rate of heat loss to the cylinder walls. But be all these things as they may, the ultimate effect is such that alcohol can be used a little more efficiently than gasoline, even in the same engine with the same degree of compression—that is, more efficiently with respect to the percentage of available heat that is transformed into useful work, but with equal efficiency with respect to the quantity of fuel consumed when the best degree of compression for each is used.

Considering only the heating values of gasoline and alcohol, it is obvious that, if other factors are equal, the relative consumption of alcohol and gasoline will be inversely proportional to their respective heating values. The low heating value of denatured alcohol, which corresponds very closely to 94 per cent by volume ethyl alcohol, will average about 10,500 British thermal units per pound, while the low heating value of 0.71 to 0.73 specific gravity gasoline will average about 19,100 British thermal units per pound. The comparison gives a consumption-rate ratio of 1.8 to 1 by weight for a thermal efficiency ratio of 1 to 1. In actual operation, however, where gasoline and alcohol were each used in the same medium-sized (10 to 15 horse-power) stationary gasoline engines without change of compression or speed, and the operating conditions, including load, were limited to the best possible for each fuel, a ratio of alcohol consumption to gasoline consumption in pounds per brake horse-power per hour was obtained as low at 0.98 to 0.59, equivalent to 1.66 to 1 by weight, or 1.45 to 1 by volume, with a thermal efficiency ratio of 28 to 26 per cent (based on the low heating value and indicated horse-power), or 1.1 to 1. By raising the degree of compression from that best for gasoline (about 70 pounds per square inch above atmospheric) to that best for alcohol (about 180 pounds per square inch above atmospheric) the consumption-rate ratio was further reduced and a ratio of 0.7 to 0.59 pound per brake horse-power per hour, equivalent to 1.2 to 1 by weight, or 1 to 1 by volume, was obtained with a thermal efficiency ratio of 39 to 26 per cent, or 1.5 to 1.

These figures are not the results of single tests, but are the average values obtained for a number of tests under identical conditions; furthermore, these values were duplicated on different engines and at different times on the same engine. They represent the best practical values that were obtained for each fuel and stated degree of compression with the equipment at hand. They were obtained under special test conditions, however, and are not commercial values; nor were they obtained offhand, even by skilled operators.

Likewise, a consumption rate was obtained as low as 0.58 pound per brake horse-power per hour for gasoline with a corresponding thermal efficiency of 28 per cent, but the compression pressure used was 90 pounds per square inch above atmospheric. With this degree of compression it is necessary to use the weakest mixtures that will explode, in order to prevent preignition, and the load had to be reduced accordingly. Heavy loads could not be carried without excessive preigniting. Similarly, a fuel consumption rate of 0.68 pound per brake horse-power per hour, with a corresponding thermal efficiency of 40 per cent, was obtained for alcohol, with a compression pressure of 200 pounds per square inch above atmospheric, but preignitions were prevented only with difficulty and by a method similar to that used with gasoline, so that the conditions under which these results were obtained were not considered practical and the values have not been used in the discussion. They do not, however, change the ratios given.

The thermal efficiencies given in this discussion were calculated from the indicated horse-power and the lower heating value of the fuel. The method employed in determining the average indicated horse-power for each load was carefully worked out and the results were very satisfactory. They are consistent throughout with the brake horse-power determinations. It is not at all impossible to obtain the average indicated horse-power with sufficient accuracy for all practical purposes, if the load is kept reasonably constant; but the indicator diagrams must be taken in a careful, systematic, and understanding manner.

The difference between the brake and the indicated horse-power, or the friction loss of engines used, was practically the same and constant. For 484 tests on the five engines the average difference was 2.3. A full description of the methods used in determining the average indicated horse-power from the indicator diagrams, with tables giving details of the tests from which the mechanical efficiency of each engine at various loads was obtained, will be given in the final report. These tables substantiate the above statements.

(To be continued.)

TRANSMISSION OF HEAT IN BOILERS.

PROFESSOR DALBY'S RESEARCHES.

PROF. W. E. DALBY placed before the Institution of Mechanical Engineers the results of a research on the transmission of heat across boiler heating surfaces. The paper is a most elaborate one, and is the most complete and up-to-date information on this most important problem. He gives a list of over 500 papers bearing on the subject which have been read and which he has carefully indexed.

The general nature of the problem is that the combustion of fuel may be regarded as originating heat energy in the furnace at a temperature so much above the temperature surrounding the firebox, that a rapid flow of heat is determined to its boundaries and across the boundaries into the water on the other side. The transmission of heat to the boundaries of the furnace takes place in two fundamentally different ways: First, by direct radiation from the incandescent fuel and the flame and the hot gases; and second, by the agency of the matter in the path of the flow; that is, the hot gases, the metal boundary, and the water on the other side of the boundary. In the first case, transmission is effected by the vibration of the ether in the same way that the heat of the sun is transmitted to the earth across space and is instantaneous. The quantity of heat radiated in this way to a first approximation may be regarded as uninfluenced by the presence of the furnace gases, although actually the quantity is modified by their presence to a certain extent. In the second case, the matter in the path of the flow transmits by convection and by conduction. Thus, in a furnace there are in general three methods of heat transmission acting simultaneously from the flame to the water, namely, transmission by radiation, transmission by convection, and transmission by conduction. It is extremely difficult to analyze the results of experiments, so that the heat transmitted by each of the three methods may be separately stated. These problems are all elaborately discussed.

In conclusion, Prof. Dalby points out that it must be confessed that notwithstanding the large number of researches and papers bearing on the subject of heat transmission there is a general absence of complete data regarding the actual phenomena occurring in a steam boiler when working under the ordinary conditions of practice. No data exist, for instance, which give the temperature gradients at different parts of a boiler flue with accuracy; isolated experiments furnish incomplete data from which the gradient may be roughly imagined, but researches and papers alike have had very little influence in modifying the general design of steam boilers. The Cornish boiler is still of the same design as it was a century ago. The Lancashire boiler has been scarcely modified in any essential particular. The locomotive boiler of to-day is a magnified type of the Rocket boiler. The most important development of recent years has been in the gradual introduction and perfecting of the water-tube type, but even in this modern product the essential features of the old types persist. This general absence of complete data is in no way due to the lack of endeavor or to the dearth of able and distinguished men in this field of research, but rather to the inherent difficulties of the problem and to the enormous cost of carrying out complete experiments upon a large boiler under the ordinary working conditions. The effect of varying the initial temperature and the flue dimensions was studied, together with the relation between the velocity of the air passing over the heating surface and the rate of heat transmission. The results show: (1) That the heat absorbed by the boiler varies almost directly as the calculated velocity of the air; (2) that the rate of heat absorption does not rise as fast as the increase in initial temperature. The curves given show that as the velocity of the air increases the true boiler efficiency of the boiler drops at first very rapidly, but after a certain velocity is reached it becomes nearly constant with a low initial temperature, and varies little with a higher initial temperature. The velocity at which, for any initial temperature, the true boiler efficiency curve becomes nearly horizontal is called the critical velocity, and the critical velocity varies with the initial temperature. Considering the mass of work which has already been done, the century of accumulated practical experience in the design, construction, and working of steam boilers, the numbers of able engineers who have devoted their attention to boiler construction and design, and the distinguished men who to-day control and influence the industry, it would almost seem that present practice represents the survival of the fittest, and that there is hardly a necessity for further research. But recent years have been fruitful in researches in other directions, and Prof. Callendar, by his brilliant work in platinum thermometry, has placed at the disposal of engineers a practical way of measuring temperatures unknown to early experimenters. We have now a means of accurately measuring the temperatures at different parts of a boiler directly. The author ventures to suggest, therefore, that a research might be undertaken by the Institution, in which steam boilers of different types working under practical conditions may be made the subject of experiments in which all the elements of their working are measured, together with temperature measurements for the purpose of establishing the temperature gradients at different parts of the heating surface.—The Steamship.

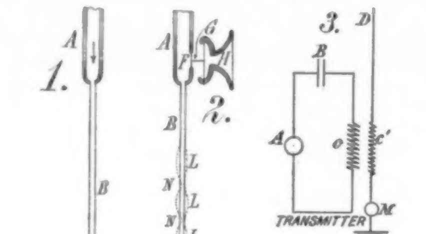
The construction of the new war signal station at Blackhead, off the entrance to Belfast Lough, is now completed. From the station, which occupies the lofty eminence at Muddersleigh Hill, a lookout can be kept on the channel on a clear day extending from the Isle of Man and Welsh coast on the south almost to the Clyde on the north. Adjoining the station there has been erected a semaphore about 70 feet high from which signals can be made directly to the Whitehead Coastguard Station, which is at present manned by an expert signaling staff, under Station Officer W. J. Collins. As one of the cross-channel cables is laid from Whitehead, the Blackhead Signal Station, when the telephonic installation is completed, will be in direct communication with the Admiralty offices in London.

MAJORANA'S WIRELESS TELEPHONE.

A NOVEL HYDRAULIC MICROPHONE INGENIOUSLY APPLIED.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

His new hydraulic microphone has enabled Signor Majorana to cover wirelessly a distance of 250 miles and more. The Italian navy is actively interested in this work, and the Monte Mario wireless post at Rome, belonging to the government, is used for the transmission. In order to find what was the range of the apparatus, the marine department used the torpedo destroyer "Lanciere" in order to carry the receiving apparatus to distant wireless stations where there was an antenna already erected. It thus proceeded first to the station of Becco di Vela, in Sardinia, which is 170 miles distant from Rome in a straight line. Here the apparatus was set up, and conversation could be heard as clearly as on a city telephone line. Next the vessel landed at Trapani, and the apparatus was placed in the wireless post on Monte San Giuliano, at 260 miles distance. Here the voice could be heard, but very faintly, and this seems to be the limit with the present height of the antennæ (280 feet at Rome and 180 feet at the other posts). With higher antennæ and a higher power there is no doubt that the distance could be much increased. The hydraulic microphone which is used by Signor Majorana in these experiments is based on a new principle, and for this reason it differs from the other types of microphone employed at the present time. If we suppose a stream of liquid to flow down from a small round opening in the bottom of the tube *A*, the stream *B* will have a regular cylindrical form below the opening and for a certain distance down, then it commences to break up at the point *C*, becoming irregular, and finally it separates into drops at the point *D*. We find that these positions are constant as long as the tube and the liquid are undisturbed, but when any mechanical shocks occur on the tube, these are found to favor the contraction of the liquid stream and the formation of drops. When shocks are given to the tube it is noticed that the point *C* occurs higher up and the drops also commence to form at a higher point. This is especially noticed when the shocks are sudden and repeated. Acoustic shocks of a vibratory nature given to the tube are also found to have an effect on the contraction of the stream and its separation into drops. Thus the sound of the voice can be made to have such an effect, provided we design the apparatus in the proper way. Signor Majorana does this, and by so adapting the instrument he makes it sensitive to a wide range of sounds such as are given within the limits of the voice, and in this case the effect upon the liquid stream is proportional to the acoustic shocks given to the tube. He is thus enabled to produce a microphone effect from the tube and the water stream, and carries this out in the following way (Fig. 2). The main tube *A* is made of a strong material which has the required thickness, and the stream *B* flows out of a round opening in the bottom of the tube. At the side of the tube and near the first opening there is an aperture which is closed by a very sensitive diaphragm *F*. A cross-rod *G* connects the diaphragm with the diaphragm of a telephone mouthpiece *H*. When we produce a musical sound, for instance, before the mouthpiece, this has a certain effect upon the water stream. Observing this effect by the proper means, we find that the lower part of the stream is made up of a series of expanded and contracted parts as shown by the dotted lines. Still farther down, the stream com-



MAJORANA EXPERIMENTS IN WIRELESS TELEPHONY.

mences to separate into drops. In general the contractions become greater as we come to the bottom of the stream. The effect is constant for any given sound, but it varies with different sounds, so that the contraction takes place higher up or lower down according to the sound, and the amount of the contraction is also different. We place in the stream two fine wires opposite each other but with a short gap between them. The electric resistance between the wires will depend upon the quantity of water which surrounds their ends. When there is a contraction at this point the resistance will be higher, and *vice versa*. We mount a battery and a telephone receiver in the circuit of the wires, and it is found that there is a sound in the receiver which corresponds to the sound made in the mouthpiece. In this way the voice can be very well heard, and with even greater clearness than with the usual microphone. There is a great advantage found here from the fact that we can use a much greater current on the hydraulic microphone than could be put on an ordinary carbon contact microphone. Seeing that the stream flows rapidly, there is a constant cooling effect which prevents the contacts from heating up from the action of the current. We make the stream conducting by using acidulated water. Mercury can also be used. To show the superiority of the instrument, it may be remarked that it was tried on the telephone line from Rome to London, a distance of about 1,200 miles, and conversation could be heard with it. At this distance the ordinary microphone will not work. The current in the microphone was about 10 amperes flowing through the liquid stream, using about 50 volts in this circuit, which is the primary. On the secondary circuit, which is connected on the main telephone line, the current is 100 milliamperes in some cases, which is ten times the usual microphone current for such cases. A good adjustment of the current can be obtained by regulating the conductibility of the liquid and also the distance between the metal points.

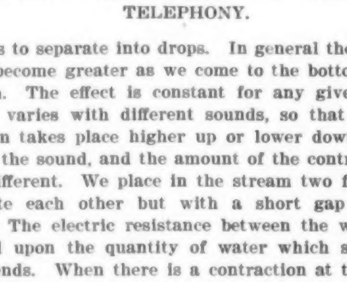
With the hydraulic microphone the following arrangement is used for long-distance telephone work. Signor Majorana uses a Poulsen apparatus for producing the waves which are needed for the transmission, such as is usually employed for this purpose. The method of connecting the instruments in the sending post for wireless telephony is shown in Fig. 3. At *A* is the Poulsen apparatus which is connected in a closed circuit with a condenser *B* and an inductor coil *c*. Parallel to the first circuit there is the circuit containing the antenna *D*. The inductor *c'* is operated upon by *c*. The hydraulic microphone *M* is placed between the inductor and the ground connection *G*. Speaking into the microphone, we produce the corresponding effect upon the waves which are sent out by the antenna, and the sounds are heard in the distant station in the telephone receiver.

The apparatus at the receiving post are shown in Fig. 4. For receiving the effect of the waves, a thermo-electric couple is employed, and the best couple for the purpose is found to be of iron pyrites and metallic platinum. The antenna *D'* is connected to ground through the inductor *F*, which is adjustable. Beside it is the second inductor *F'* forming part of a closed circuit including the condenser *H*. Connected in shunt around the condenser is the circuit which contains the thermo-electric couple *K* and a condenser of very small capacity *J* in series with the latter. In shunt upon the thermo-electric couple is the telephone receiver *T* and a sensitive galvanometer *L*. When waves are received in the antenna, the circuit *F H* is accordingly affected and a portion of the energy of this circuit passes in the shunt *J K*. The thermo-couple is therefore heated, and it sets up currents in consequence. Such currents pass in the telephone receiver and produce sounds which correspond to the original sounds. The galvanometer is used to observe the telephone currents in order to regulate this circuit properly. Signor Majorana also uses the De Forest *audion* and obtains even better results than in the above case.

THE HUMAN STORAGE BATTERY

An "attraction" bearing the pompous title of "the human storage battery" has recently been exhibited at popular festivals in Paris. The showman introduces a young man who, he asserts, has tamed the mysterious and terrible force of electricity and made it so subservient to his will that he can, with impunity, produce brilliant sparks and electric lights from his body. After explaining the effects of induced currents, the lecturer sets into operation a large Ruhmkorff coil, in which the induced current has a tension of 40,000 or 50,000 volts, and asserts that the young man's body spontaneously generates a current of equal intensity. To prove the truth of this statement, the young man seizes a huge Geissler tube, which instantly begins to glow. Several tubes, containing various rarefied gases, and an ordinary electric light bulb are caused to glow by the touch of the young man's hand. The experiments are performed on a small stage draped in black, but several of them are repeated on the ground, within a few feet of the spectators.

These surprising effects are produced by the employment of the D'Arsonval coil and alternating currents of high frequency, and the experiments can be repeated by any person placed within the magnetic field of those currents. For the exhibitions described above it was merely necessary to make the D'Arsonval coil very large and to construct and arrange it in such a manner that its magnetic field should embrace the little stage and the platform in front of it. The apparatus was concealed from the spectators by the black



THE HUMAN STORAGE BATTERY.

hangings, but an attentive observer could detect the peculiar sound of the interrupter of a Ruhmkorff coil whenever light was evolved from "the human storage battery."—La Nature.

BURMESE FIRE-MAKER.

Prof. O. P. Monckton, of Sibpur C. E. College, Calcutta, writes that the Burmese have discovered for themselves the well-known scientific fact that if air (or any gas) be suddenly compressed, a rise of temperature immediately occurs, and have made a most practical use of their discovery.

Perhaps it was the practical use rather than the scientific fact that they discovered. Burmah is a damp place in certain localities, and matches have yet to penetrate the innermost recesses. The appliance used instead consists essentially of a small, strong cylinder, generally made of buffalo's horn, with a hole about ¼ inch diameter bored in the center very nearly to the bottom. In this cylinder a piston fits, as accurately as the Burman knows how to make it, while the length of the piston is slightly longer than the length of the cylinder. In the bottom of the piston a small recess is cut to take a piece of dry pith, or some other inflammable material. The Burman puts the piston into the cylinder, strikes a smart blow, quickly takes out the piston and blows on the pith, and a flame promptly results, the *raison d'être* of the whole being the scientific laws connecting the pressure, temperature, and volume of a gas.

Thus, taking the cylinder to be ¼ inch diameter and 2 inches long, that the piston is driven to ¼ inch of the bottom, and assuming that temperature of the outside air is 80 deg. F., the ordinary formula tells us that the temperature inside the cylinder is about 790 deg. F. In practice some heat is given out during the progress of the compression, while the cylinder never fits perfectly airtight. Prof. Monckton estimates that a loss of at least 25 per cent might be expected. —English Mechanic and World of Science.

VENUS AS THE ABODE OF LIFE.*

THE MYSTERY OF A CLOUD-VEILED PLANET.

BY F. W. HENKEL.

OF all the heavenly bodies, the sun and moon only excepted, there is probably none of more interest to us than this planet. Approaching at times to a distance less than that of any other star, the great variations in its distance from us cause corresponding variations in luster. Though many speculations as to the possible inhabitants of Mars and their supposed engineering works (the so-called "canals," etc.) have been mooted with more or less ingenuity, in our opinion the probabilities in favor of the habitability of Venus are vastly greater. This planet, says Prof. Young, is "the earth's twin sister in magnitude, density, and general constitution." Though its distance from the sun is less than three-quarters that of our own earth (about 67,000,000 miles), varying only very slightly (its path being the most nearly circular of any known planet), and consequently any given area of its surface must receive about twice as much heat as we receive on an equal area, yet this is probably mitigated by the presence of a more extensive atmosphere laden with water vapor. From time to time different observers have deduced differing periods for the length of its day, but the most probable period seems to be about 23½ hours, or rather less than our own day. Its year (owing, of course, to its greater nearness to the sun and its swifter motion) is only about 225 days, its speed in its path round the sun being 23 miles per second. Its diameter is 7,700 miles, while that of the earth is about 7,900 miles, so that the planet is slightly smaller, its mass (or quantity of matter) is rather over three-quarters that of the earth, and consequently the average density of the materials composing it is 86 per cent of the terrestrial density. A body dropped from a point near its surface would acquire a velocity of 27 feet per second at the end of one second, instead of 32 feet per second as here, and would move over 13½ feet during the first second of its motion. Surface markings have been seen from time to time upon the planet, more distinctly observed in Italy and other more favored latitudes than our own. On account of its general proximity to the region of the sky in which the sun is found, and its great brilliancy in the telescope, Venus is by no means an easy object to scrutinize with satisfactory results.

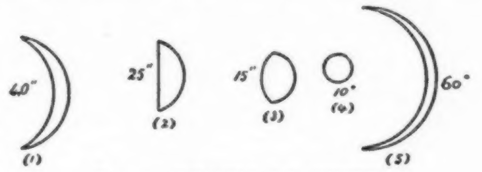


FIG. 1.—PHASES OF VENUS.

1 and 5, near inferior injunction; 2, at greatest elongation; 3, at gibbous phase; 4, superior conjunction.

However, its phases or changes of appearance, like the moon, are easily perceived with very small optical aid, and were among the first fruits of the invention of the telescope, exactly three centuries ago. Galileo, who first discovered that the planet exhibited the crescent phase and the other appearances presented by the moon, announced his discovery in a curious anagram, which being interpreted read (in Latin) "The Mother of Loves (Venus) imitates the phases of Cynthia (the moon)." The explanation of these phases is precisely similar to those of the moon, and their appearance was a strong confirmation of the truth of the Copernican theory. Venus being an opaque body is visible only by the light which she receives from the sun and reflects. The hemisphere turned toward the sun is, of course, illuminated, the other side in darkness; more or less of the illuminated hemisphere being turned toward the earth at different times. When the planet lies beyond the sun, turning toward the earth the whole of its illuminated hemisphere, it is seen (if not too close to the sun's place in the sky) as a small round disk. Fig. 1 (4). When at its greatest elongation east or west of the sun, about half the illuminated side is turned toward us and the planet is seen like the moon half full, but owing to its greater proximity appears half of a considerably larger disk than before. Fig. 1 (2). Near inferior conjunction, i. e., where the planet is between earth and sun and on the same side of it, the planet is seen as a very thin crescent of large size, as it is then at its nearest to us. Fig. 1 (5).

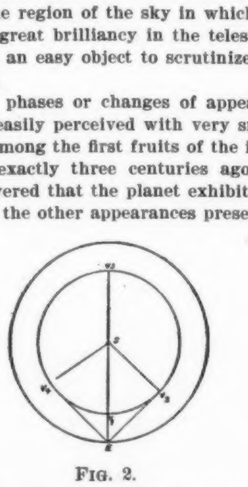


FIG. 2.

S, Sun; V, Venus; E, Earth; V_1, Inferior conjunction; V_2, V_4, Greatest elongations; V_3, Superior conjunction.

The planet is brightest (to us) about 36 days before and after inferior conjunction.

From Fig. 2 we may see the great variations in distance of this planet from the earth—least at V_1 and greatest at V_3. Also, since at greatest elongation the angle EV_2S is a right angle, by observing the angle of elongation SEV_2 we may find the proportion SV_2 bears to SE, or the ratio of Venus's distance from the sun to the earth's distance, for $\frac{SV_2}{SE} = \sin SEV_2$ and the angle of elongation SEV_2 is 47° $\therefore SV_2 = SE \sin 47° = 0.73$ (SE being taken as unity) or, as we have already stated, Venus's distance is rather less than three-quarters that of the earth from the sun.

From certain irregularities observed upon the terminator, or boundary of the limb, and the blunted appearance of one of the cusps of the crescent, various observers have concluded that there exist high mountains upon the planet's surface. Sometimes when the planet is in the crescent phase intensely bright spots have been seen near the polar regions, which may perhaps be ice-caps like those seen on Mars. Darkish markings, indicating continents and seas "dimly visible," are also at times seen, and a rough map of Venus was made by Bianchini long ago. His observations were confirmed by thousands of observations made by De Vico and his assistants, so may be considered to represent real features of the surface.

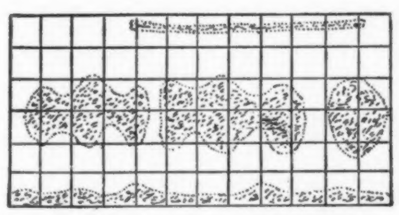


FIG. 3.—BIANCHINI'S MAP.

We have already stated that there is evidence of the existence of an atmosphere, and from observations of the transit of the planet across the sun's disk in 1874 it was concluded that the atmosphere is about 1½ times to twice as extensive as our own. The existence of water vapor has been shown by the spectroscope.

At times the dark portion of the planet, unilluminated by the sun's light, has been faintly visible, from which it has been considered probable that phenomena of the nature of the auroræ take place from time to time upon Venus. So far as known, the planet has no satellite or moon attendant upon it, but to a great extent the want of a moon is made up for, to the possible inhabitants, by the earth. When Venus and the earth are nearest, as we have already said, they are on the same side of the sun, and the planet, turning its dark side toward us, is invisible, like the moon when new. On the other hand the earth has the whole of its illuminated side turned toward the planet, is on the opposite part of the sky to the sun, and is consequently visible as a brilliant object ("full earth") in the night sky of the planet. We know from the phenomenon of earth-shine that the earth reflects a considerable quantity of light to the moon, part of which is again reflected back to us, and if we suppose the intrinsic reflecting power of the earth's surface to be equal to that of Venus (it may be, indeed, and probably is, considerably less) it must give much greater light to the planet and be a much more brilliant object in its sky than Venus ever appears to us, owing to the following circumstances. When brightest only a small part of the planet's illuminated surface is turned toward us, but even so it appears more conspicuous than any other star or planet in our sky, and is often visible in daylight. On the other hand the whole of the earth's illuminated hemisphere is turned toward Venus when they are at their nearest together, and the earth is then on the meridian at the planet's midnight, being in "opposition" to the sun. Thus as a night luminary the earth to some extent plays toward Venus the part the moon does for us.

Occasionally Venus passes directly between the earth and the sun at inferior conjunction, and is seen projected as a black dot on the sun's surface crossing it from east to west, sufficiently large to be visible to the unaided eye. Ordinarily, owing to the fact that the plane of its path is inclined at a small angle (3½ deg.)

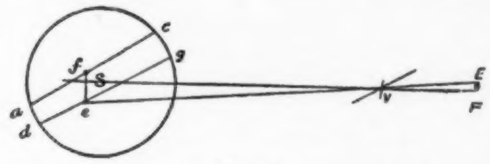


FIG. 4.

EF, Earth; V, Venus; S, Sun; $a\,f\,c$, Planet's path seen from F; $d\,e\,g$, Planet's path from E.

to the plane of the ecliptic (earth's path), it passes a little to the north or a little to the south of the sun's place. These transits across the sun's surface have a special interest for astronomers, owing to their affording an opportunity for determining the sun's distance from the earth with great accuracy. Accordingly expeditions have been made to distant parts of the earth to observe these transits when they occurred. The transit of 1769 was observed by Capt. Cook at Otaheite, he having been sent by the government of that date to the South Seas at the request of the Royal Society. The transit of 1882 was visible in this country, and was also observed in various other parts of the world. When Venus passes between the earth and sun she is at her nearest to us—between three and four times nearer than is the sun. Consequently, as seen from different parts of the earth, Venus will be seen to cross different portions of the sun's disk, and by exactly determining the planet's path as seen at the different stations whose distance from one another is known, it is possible to determine both the planet's and the earth's distance from the sun. In Halley's method two stations at which the transit is visible are chosen, the stations being one as far north and the other as far south as possible. The duration of transit (i. e., the time occupied by the planet in crossing the sun's disk) is observed at each station, and knowing the planet's velocity in its path, the length of the chords $a\ f\ c$, $d\ e\ g$ is known, the displacement $f\ e$ being the measure of FE at the sun (while from the similar triangles EVF, $e\,V\,f$ we shall also get $EF : ef :: VF : Vf$, etc.). (Fig. 4.) Knowing the ratio of VF to $V\,f$, and the distance EF, all the other distances may be thus easily found (in miles, etc.).

There are, however, practical difficulties in the way of determining the exact instant the planet enters and leaves the sun's disk, different observers having obtained differences of about ten to fifteen seconds of time, though observing side by side. The atmosphere of Venus causes its edge to be more diffuse than would otherwise be the case, and the phenomenon of the black drop, at internal contact, also complicates matters.

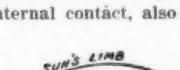


FIG. 5.

Instead of touching sharply, a kind of ligament or "black drop" extends from the planet to the sun (Fig. 5), a similar effect to that which is observed when we bring two fingers in contact and then hold them up to the light and separate them; as they separate a "black ligament" will appear to connect them for a short space. By means of photography, it was attempted to render the results more certain; but so far the photographic methods give no better satisfaction than the others. It is now generally considered that the transit of Venus method, though admirable in theory, has proved of less value than was expected, in practice, and by the time the next transit comes round (there are no more till 2004 A. D., nearly a century hence) other methods are likely to have given better results.

We have seen that there is evidence of the existence of continents and seas, air, and water vapor upon the planet. The amount of sunlight it receives, though greater than our share, is not excessively so, for there

* Knowledge and Scientific News.

appears reason to believe that polar snow-caps exist, and in other respects, for conditions favorable to the existence of beings organized not very much unlike those with which we are familiar on this earth, we have as much evidence as we can reasonably expect. We may thus conclude that the planet is in most respects not dissimilar to the earth, and is the abode of life, at least in the regions north and south of the equator, if not on the "torrid zone" itself.

INTERNATIONAL OCEAN RESEARCH.*

A PHYSICAL AND BIOLOGICAL SURVEY OF THE NORTH SEA.

BY A. E. SHIPLEY, M.A.

As an example of international co-operation in scientific research I may take the investigations which have been going on for the last seven years in the Baltic Sea, in the North Sea, and in that great Norwegian Sea which stretches from the western coast of Norway north to Spitzbergen and westward beyond Iceland and the Faroes. In this inquiry no less than ten nations—in fact, all those whose shores touch these seas —have had a share—England, Scotland, Norway, Sweden, Finland, Russia, Germany, Denmark, Holland, and Belgium; and since most of these countries have a special steamer equipped for research and under the command of men trained in scientific methods, it has been possible to collect a mass of facts connected with the seas of northern Europe such as has never been got together before for any similar area of the ocean.

The aim of those responsible for the scheme of work was to obtain as complete a survey as possible of the physical and biological conditions of the seas in question. They wanted to know the direction of ocean currents, both superficial and along the bottom; the variations in the degree of salinity of the water in time and in space; the nature of the sea-bottom, and whether this could be correlated with the fauna, sessile or moving, found upon it, and whether this fauna reacted on the prevalence or absence of food-fishes; the influence of depth, salinity, and temperature on the fauna; the seasonal variations and fluctuations of the small floating organisms often called the plankton; the life history of our food-fishes, where and when they deposited their ova; what became of the ova; the distribution of the larval stages; the age at which the fish become mature, and their average length of life.

Then, again, it was hoped that much could be learned about the influence of man's activity on the sea. The relative depletion of the fish population caused by different modes of fishing; the intensity of trawling; how often does the trawl pass over the same ground in a given time? The question whether or no the seas are being over-fished, and, if so, what measures can be taken to lessen this evil, either by close time, limiting the size of fish captured, or by artificial fish-breeding. Many of these last-named problems concern the legislator as much as the man of science. The function of the latter is to provide facts upon which the administrator may act.

Such a vast task as was set out by the International Council in 1902 has necessitated an immense organization. Some eight or ten steamers are employed making periodic voyages, under the direction of trained men of science. Enormous numbers of temperature-readings, investigations into the speed and direction of currents, and chemical analyses of sea-water have been recorded, and thousands of samples of the bottom, of the animals and plants living thereon, of fish in all stages, millions of fish ova, have been collected and accurately determined. To work up such an amount of material has occupied the attention of a large number of naturalists. Each country has at least one large laboratory devoted to this work, and their results are co-ordinated and generalized by the central bureau. The English part of the work was intrusted by the Lords of the Treasury to the Marine Biological Association, and has been carried out under the direction of Dr. E. J. Allen and Prof. Walter Garstang at our laboratories at Plymouth and Lowestoft.

Although all the ten countries are working upon what is, broadly speaking, a common plan, each has had its own special problems. In addition to carrying out the broad outlines of an international scheme, they have specialized along lines indicated by their own needs, and have attacked problems whose solution affected their own special food supply. Thus Norway, where the old open fishing boat is being replaced by the modern, decked trawler, has especially studied the cod and the saithe, the haddock, and the herring, and has devoted much time and labor to the discovery of new fishing grounds, and has successfully done this along the Norse coast, in the Arctic circle, and on the banks between the Faroe Islands and Iceland. They have further established a trade in *Pandalus borealis*, allied to the prawns, which are taken in the deep waters off Norway, and are now to be bought in most fishmongers' shops in Great Britain.

* Abstracted from a paper read before the Zoological Section of the British Association for the Advancement of Science.

In a similar way the Danes have tracked the eels as they leave the estuaries of the great rivers of Central Europe across the North Sea to the deep Atlantic off the west of Ireland, just beyond the 1,000 fathom line. In these depths they spawn and the resulting larval form, the *Leptocephalus*, long thought to be a separate genus, lives there for a while, until, gradually changing into an elver, it retraces by some mysterious instinct its parents' path across the ocean and regains the fresh-water rivers which those parents had left.

The English share of the investigation is limited to that part of the North Sea which lies south of the latitude of Berwick, and for the most part to the western half of the seas and to the English Channel; the latter, as we shall see, is a very important area. The work, so far as it has been specialized, deals, in the North Sea, largely with the plaice, with the food of fishes generally, and with the character of the deposits forming the sea floor, with the creatures growing thereon. In the channel the English worker is entirely responsible for the study of the hydrography of the water, which, entering the North Sea through the Straits of Dover, contributes greatly to its mass.

As a result of Prof. Garstang's investigations, an important spawning ground of the plaice has been located in the southern bight of the North Sea; the migration of both sexes has been traced to these grounds on the advent of the spawning season, and their return to their feeding grounds in the spring has been followed. During the spawning season it is usual to catch more males than females on the spawning grounds, possibly because at this time the female is inert and elusive, while the male is unusually active.

The course of the ova has been traced, chiefly by the Dutch investigators, as they drift toward the shallow fringe of coastal water, by far the greater number along the continental coast. Here the young fry grow up, and after attaining a certain size they leave the shallow coastal waters for the deeper seas off shore. Comparatively few of these, however, reach the feeding ground of the Dogger Bank, and Garstang has been able to show that by carrying the young plaice in steamers and transplanting them at the proper time on to this rich feeding ground, their rate of growth can be greatly accelerated and thus their market value largely increased, just as Dr. Petersen has done in the case of plaice on Thisted Bredning.

A few years ago there was no reliable method of determining the age of fish. Petersen's method of arranging the measurements of a large number of specimens in a scale according to size, when they resolved themselves into certain groups, which were considered to coincide with age-classes, has been superseded by the discovery of Reibisch, Heincke, and others, that many of the bones, the scales, and the otoliths of fishes show annual age-rings, like those found in the trunk of a tree or in the horns of cattle. By laboriously counting the rings on the otoliths of thousands of plaice, Dr. Wallace and others have been able to determine their rate of growth, and to show that some specimens attain the age of twenty-five and even twenty-nine years. Similar investigations have shown that the sexes have a different rate of growth. The age at maturity is found to differ in different regions, but in the majority of cases Wallace found that the males are sexually mature (four to five years) a year before the female is capable of spawning (five to six years). We can now correlate age with size and with weight.

The migrations of the plaice and of other fish and their rate of growth depend, among many other factors, upon their food supply. And the nature of the food of fishes has recently been re-investigated in the North Sea. I give some of Todd's results, which were made by the examination of some thousands of fish of thirty-one species. Of these I select three—the cod, the plaice, and the dab.

Percentages of Stomachs Containing Various Kinds of Food.

Cod.

Size of fish in cm.	0—15	15—30	30—60	60+
Pisces	0 p.c.	11 p.c.	52 p.c.	67 p.c.
Mollusca	0	2	16	4
Crustacea	100	95	67	63
Polychaeta	0	9	9	26

Plaice.

Size of fish in cm.	0—10	10—20	20—30	30+
Pisces	0 p.c.	1 p.c.	5 p.c.	5 p.c.
Mollusca	17	66	76	84
Crustacea	57	16	13	11
Polychaeta	38	37	51	42
Echinoderma	0	20	13	6

Dabs.

Size of fish in cm.	0—10	10—20	20—30	30+
Coelenterata	0 p.c.	18 p.c.	18 p.c.	20 p.c.
Echinoderma	0	26	25	2
Polychaeta	30	22	20	10
Crustacea	70	30	35	61
Mollusca	2	48	57	65

These tables show what, of course, was more or less known before, that as a rule the young fry live very largely, and in many cases solely, on crustacea. To a great extent the supply of suitable food dominates the movement of the young fry, for nowhere is the truth of the Frenchman's definition of life, "I eat, thou eatest, he eats," with its terrible correlative, "I am eaten, thou art eaten, he is eaten," more true than in the sea. Later in life the fishes' taste alters, and with increased size they can tackle animals whose calcareous deposits would seem to render them highly indigestible.

Very careful investigations have been made and are being made by Mr. Borley and Mr. Todd as to the distribution of the fauna of the middle and southern parts of the North Sea, and its relation to the depth of water, the varying degree of salinity, and to the texture of the bottom deposits. These results, however, have not been published, but I may go as far as to say that the inquiry shows that within the area investigated the texture of the sea floor has, on the whole, more influence on the distribution of the invertebrates of the bottom fauna than has depth, and that depth in the area in question seems to have more influence than salinity.

With regard to the character of the bottom deposits, it has been found by Mr. Borley that off shore and on the gently shelving continental coast the sea bottom is of a uniform character over wide areas, though on the western side it is more patchy; and it has proved possible to divide the samples taken into some nineteen main types, each characteristic of one or more of the areas into which the region has been split up. Only one or two details of this laborious work can be mentioned. One is that the texture or degree of coarseness of the ground in various parts of the sea is such as to suggest that the distribution of the finer grades of material, the finer sands and silts, is greatly influenced by the joint action of currents and tides. It is, for instance, known that in the southern part of the North Sea the main direction of the bottom current is to the north and then to the east; and examination of the deposits shows a regular diminution in the proportion of the coarser sands, a regular increase in the proportion of finer material, as we proceed from the Straits of Dover in a northeasterly direction. A remarkable fact in this connection is the complete absence of silt from the sandy bottom west of the mouths of the great rivers Rhine and Maas. There can be no doubt that the presence of broad and shallow stretches of sand on the continental, but not on the English, side of the North Sea is one of the factors which has determined the distribution of the small plaice, which on the continental shores are so extraordinarily abundant, and on the English shores are relatively so scarce.

By means of bottles weighted with shot, so as to have about the same specific gravity as the surrounding sea water, Mr. G. P. Bidder has been able to trace slow currents moving over the bottom of the sea. The bottles are closed, and contain a post card in many languages, offering a reward to whosoever returns the post card, recording the latitude and longitude of the place it was trawled at, to our laboratory at Lowestoft. Attached to the neck of the bottle is a copper wire 1½ feet long. This wire trails along the bottom, the bottle itself floating about 1¼ feet above the level of the ground. Slowly as the bottles are swept along, yet the distance they cover is sufficient to sharpen the free end of the wire to a needle point.

By these and by other methods it has been possible to trace the almost imperceptible but steady flow of waters along the bed of the sea. Without doubt these currents influence the distribution of the larval and

young forms of all the creatures which live near the bottom, and especially influence the migration of food fishes in their younger and less active stages, when they are swept helplessly along.

But these bottles have a double lesson to teach us; not only do they enable us to chart the slow streaming of the bottom water, but they give us to some extent a measure of the intensity of trawling in the North Sea. They have been refished in really surprising numbers. Commercial trawlers have retaken them at the rate of 58 per cent per annum. In one area these bottles cast upon the waters were retaken, not after many days, but after very few. Out of 390, eighty-five were recovered in six weeks, and fifty out of 270 were trawled in five weeks, representing a local intensity of fishing which if continued would give us between 80 per cent and 90 per cent of recaptures in a year.

Marked fish which have been liberated and recaptured tell the same story of intensity of fishing.

The intensity of fishing as indicated by the percentage of recaptures within twelve months of liberation is shown by the following table:*

Off Shore.	Percentage.	
	Fish Under 25 Cm.	Over 25 Cm.
Dutch coast	23.7	20.3
Deep water, Southern Bight	13.0	26.6
Leman Ground (liberated April and May)	18.7	17.4
Leman Ground (liberated December)	—	21.0
Horn Reef outer ground	33.3	23.0

Obviously, since some fish are known to have been captured but not returned to the laboratory, the method gives a minimum estimate.

By applying the same method to the marking experiments of other countries as well as our own, Garstang† gave the percentage recovered within twelve months of liberation of fish over 25 centimeters in length as from 4 per cent on the Fisher Bank to 56 per cent in the Skager Rak.

When we reflect on the chances of these marked fish dying or being eaten or losing their labels, it is surely a most remarkable fact, full of significance to the practical man, that in the North Sea marked fish of marketable size are recaptured at the rate of between 20 and 30 per cent each year, and sometimes at a greater rate. It would seem that each square yard of the fishing grounds is swept by the trawl not once, but again and again each year.

* Garstang, North Sea Fisheries Investigation Committee Southern Area, Report No. 1.

† Provisional Report on the Natural History of the Plaice (Committee B), Procès verbaux, vol. iii.

Mr. Borley has conducted a large series of experiments to determine the vitality of fish after they have been captured by both the beam and the otter trawl. It was necessary to determine the degree of injury caused by the actual trawling, the raising of the trawl, and the subsequent exposure on deck. The larger fish of both sexes were capable of resisting the damage to a greater extent than those of smaller size, and the relative resistance of the two sexes varied at different sizes, the male showing a decline in the increase of its vigor as it approaches maturity. One factor which is very deleterious to the fish is the presence of jellyfish in the trawl; these either smother the fish or possibly sting them to death; at any rate, the mortality of the fish is enormously increased when medusæ are present in any numbers. The otter trawl is also far more harmful than the beam trawl, and exposure on deck to a hot sun is another constant source of death, one hour's such exposure in one series of experiments killing 99 per cent of the smaller fish. In the ordinary commercial operation of trawling, while the fish are being sorted those that have no market value lie about on the deck of the vessel for at least an average period of one hour; hence it is extremely probable that when shoveled overboard practically all are dead or dying.

The work which has been done by our own special steamer has been supplemented by records carefully kept by certain selected captains of commercial trawlers, which sail from Grimsby or from Lowestoft. In this way the details of some 20,000 hauls have been examined, and their results tabulated by Miss Lee.

I have left myself no time to describe the important hydrographical investigations carried on by Mr. Mathews into salinity, temperature, etc., which show us the conflicting currents at the mouth of the English Channel and how the North Sea in its southern part is supplied with water from the Atlantic through the Channel. The curious ebb and flow of the Gulf Stream, its periodic welling up and subsidence, closely connected as they seem to be with the migrations of the herring, cod, and haddock shoals, is another most important matter of investigation.

Neither can I tell you in detail of the immense amount of work which is being done by the other countries which share in the international scheme, by the Scottish Fishery Board, the pioneer in Great Britain of this sort of research. To the west our Channel work is beginning to get into touch with the more recently established Irish Fishery Board, and with the work carried on under the direction of Prof. Herdman in the Irish seas.

The outcome of all this minute and continuous investigation, will, in time, tell us whether or no the North Sea fisheries are being exploited in the most profitable way—a very important question for our country, for with a fishing fleet of 27,000 vessels, manned by 90,000 fishermen, who land 900,000 tons of fish a year, valued at £10,000,000, Great Britain takes 90 per cent of what is caught in the North Sea. Some statistics indicate that there is a falling off. The steam trawlers in 1905 landed 25,000 tons of fish less than in 1904, and in 1904 there was a similar shortage on the total of 1903. And yet 1903 was a year in which some crisis took place; the growth of the haddocks and the number of young haddocks were far less than normal, the Norwegian cod fisheries sank to a minimum, the French statistics showed the same feature in their fisheries off Iceland. In 1903, however, there were unusually large numbers of small plaice. The polar ice field pressed down south, and seals, cetacea, and Arctic birds left their usual quarters, and came south in some cases as far as Shetland.

The gigantic climatic changes which are indicated by the above-mentioned decline undoubtedly disturbed for a time the rate of increase and the rate of growth of the fish population of the North Sea; but they soon returned to their normal state. Compared with such mighty influences the fishing activity of man seems almost negligible, and Dr. Hjort for one thinks that "the productiveness of fish" "may be regarded as independent of the interference or fisheries of man." I am not sure that this is so. Taking large areas and all fish into consideration, it may be true; especially it would seem to be so of some species such as the herring, the saithe, and the cod; but in certain areas and with certain fish, such as the sole and the plaice, man's activity has undoubtedly decreased the number.

Although the researches of the last few years have immensely increased our knowledge of what is going on in the sea, they have, like an ever-widening circle, but increased the number of problems which await solution. It is earnestly to be hoped that the work may go on on at least its present basis. The business man, always on the outlook for a dividend, has sometimes complained that some of our inquiries do not seem to him practical, but he must have patience and faith. A few years ago no knowledge could seem so useless to the practical man, no research more futile than that which sought to distinguish between one species of a gnat or tick and another; yet to-day we know that this knowledge has rendered it possible to open up Africa and to cut the Panama Canal.

WHAT IS CORDUROY?

THE ORIGIN AND USE OF THE WORD.

There is a small class of words and phrases in our language which are of French appearance, but of English invention; and "corduroy" is an example. The king's cord suggests a fabric of some magnificence originating at the court of "le Roi Soleil," or in some other monarchical connection; and yet the name is unknown in French. The "corde du roi" which would seem to be the natural French source for an Anglicized "corduroy" is simply an imaginary phrase. The French language knows it not. Sir James Murray points this out in his great dictionary, and adds that not only has no such name ever been used in French, but on the contrary, a list of articles manufactured at Sens in 1807 enumerated "etoffes de coton, futaines, kings-cordes," where the word is evidently borrowed from the English, there being no French equivalent.

The corduroy, which is so familiar a part of the clothing material of laborers and men engaged in rough, hard work, and which certainly is a thick-ribbed corded stuff, may owe its name to the imagination of the inventor, whoever he may have been, who may have thought to recommend his stuff by the bestowal thereon of a name which, while indicating in part the nature of the material, would also suggest an origin of some magnificence; or, as it has been suggested, the inventor himself may have borne the English surname of Corderoy, just as Macintosh gave his name to the waterproof material he introduced. When Sir James Murray, with all the resources of the Oxford Dictionary material and staff at his disposal, is unable to offer any solution of the problem, the question of the word's origin may be regarded as one of the insoluble puzzles of the language.

The curious thing is that in all the researches which have been made for the dictionary the word "corduroy" has not been found, by some years, at so early a date as the simple "cords." Under either name the fabric seems to have been unknown before the second half of the eighteenth century, when velveteen cords, fancy cords, etc., soon became recognized trade terms. The strength and serviceableness of the material quickly made it popular with those to whom such qualities in clothing were of the first importance. All men, whether laborers or huntsmen or the like, who worked hard or who took exercise involving much wear and tear, must have welcomed the strongly ribbed fabric. Canning's "Weary Knife-Grinder" wore it—

"His galligaskins were of corduroy
And garters he had none."

Scottish mothers, with a knowledge of boy nature and a canny appreciation of economy in material, made use of it. Lord Cockburn, in the "Memorials of His Time," says that when he went to the High School at Edinburgh about 1790, the usual dress for a boy was a single-breasted jacket, which in due time got a tail and became a coat; brown corduroy breeches, tied at the knees by a strong knot of brown cotton tape, worsted stockings in winter, blue cotton stockings in summer, and white cotton for dress. An Edinburgh High School boy of the present day would look rather askance, it is to be feared, at such a "get up," but it must have been an eminently serviceable, wear-resisting costume.

A little later there are many allusions to the use of a variety of "cord" by sportsmen. Hook, in "Jack Brag," describes a "sprightly gentleman in the scarlet jacket and white cords," and Lever clothes another in "a green coat of jockey cut, a buff waistcoat, white cords." And "cords" still remain an important feature of the tailor's work for country wear. There is, of course, corduroy and corduroy. Besides the thickly-ribbed stuff that makes the navvy's trousers, stringtied or strapped below the knee, there have been and are various more dainty varieties of fustian, ribbed and colored somewhat similarly, used for children's clothes and the like. Nearly twenty years ago dressmakers used a fabric striped in tiny ridges which was known as "corduroy crepon," though the ridges were merely miniatures of the furrows in corduroy. But these and similar materials are fanciful developments, which, although they seem to justify the name, have little in common with the original stuff.

Yet one other variety of corduroy there is; or at least one other application of the name, which is quite unknown here, but was once familiar enough in the backwoods of America. This is the corduroy road—a very graphic name for the rough kind of causeway formed by laying trunks of trees transversely across swampy or soft ground. The books of early travelers in the United States and in Canada, especially in the backwoods settlements, abound in references to these bumpy, very trying roads. Dickens, in describing one of his transatlantic journeyings in his "American Notes," says: "A great portion of the way was over what is called a corduroy road, which is made by throwing trunks of trees into a marsh and leaving them to settle there." Such a road may be safe, but it makes far from comfortable traveling. One early traveler in Canada describes feelingly how "over these abominable corduroys the vehicle jolts, bumping from log to log." A jerry-built "buggy" would not stand much traveling of that kind. Roads of the corduroy order were often hurriedly made for military purposes in the American civil war, and similar roughly constructed causeways are not unknown in other countries. Miss Bird mentions them in her travels in Japan, and there used to be a "corduroy bridge" over the Slomgen River in Norway. It is a far cry from the original corduroy, the honest, ribbed fustian of the laborer's clothing, to these rough forms of elementary roadmaking, but both serve excellently the purposes for which they were intended.—London Globe.

The voluminous report prepared by Dr. Frederick A. Cook for the University of Copenhagen, setting forth in detail his claim to having reached the North Pole, was taken on board the Scandinavian-American liner "United States" on Thanksgiving Day and started on its way to Copenhagen. The report is said to consist of 50,000 words. The report will reach Copenhagen on December 7th and a verdict by the university some time between December 25th and January 1st may be expected.

ENGINEERING NOTES.

A summary of the reports received from mines inspectors in the United States shows that there were 2,450 men killed and 6,772 injured in the coal mines during last year. These figures compare with 3,125 killed and 5,316 injured in 1907. Colossal as these figures are, they do not represent the actual total, as there are several States in which no mines inspection law is in operation. It is fair to say, however, that these States which report accidents contribute over 98 per cent of the total coal output of the country. The year 1907 was the worst in the history of the United States as regards the number of lives sacrificed in the mines. This was due to the succession of serious disasters that occurred in December of that year in the Appalachian bituminous coalfield, each involving a heavy death roll.

A large centrifugal pumping plant is being built for the new Alexandra Docks of the Newport Docks Company, at Newport, England. The plant will consist of two pumps, each direct-connected to a triple-expansion steam engine, each unit having a maximum capacity of about 1,200 brake horse-power. In pumping water into the dock from the River Usk, the two pumps combined will handle 50,000,000 gallons in 5 hours, or each unit will handle about 80,000 gallons per minute, when running at 90 revolutions per minute. The same pumps are to serve subsequently in pumping out a graving dock (not yet built), and in this work will run at speeds up to 120 revolutions per minute, discharging 100,000 gallons per minute each, against a head of 42 feet. The pumps are being built by Willans & Robinson, of Rugby, and were designed by J. Orten-Boving & Co., of London. In planning this pumping plant, the question of electric driving or direct steam driving was investigated, and on account of the varying heads to be pumped against the steam driving was selected as most economical.—Engineering News.

In view of the unsatisfactory results obtained during the cholera epidemic, which has lasted more than a year, in connection with the purification of the water of the Neva by means of ordinary sand filters, the water-distribution system being exposed to constantly renewed cholera infection, the municipal Duma and city authorities have decided to adopt the ozone process for the sterilizing of drinking water, and to erect a large ozone waterworks. The sanitary authorities both of the city of St. Petersburg and the state are, in fact, of the opinion that only by the ozone method will effective purification of the drinking water of St. Petersburg be obtained, as their own investigations, in agreement with those of the German Imperial Sanitary Office and the Pasteur and Koch Institutes, have shown ozone to be the safest means of insuring the complete destruction of bacteria in water. The large ozone works which is to be installed in connection with what is called a "rapid filtering plant" (Howatson system) is to be designed according to the combined Siemens-De Frise-Otto ozonizing system.

A remarkable tunneling record has been made in one of the tunnels of the new aqueduct for the water supply of Los Angeles. The progress in the Red Rock Tunnel—75 square feet sectional area—was 1,061 feet during the month of August, working three shifts of thirteen men in one heading in sandstone. This is a "world's record," the previous record being the 1,013 feet progress of the Loetschberg railway tunnel in Switzerland for the month of July. Up to this time American records have been far behind European records, the highest figures having been only 476 feet. It is of interest to note in this connection that the Red Rock Tunnel is not being driven by a contractor's force, but by a part of the forces organized by the city's engineers for the construction of the new aqueduct system which will give the city a new and abundant supply of water from mountain reservoirs 235 miles distant from the city. After due consideration, the city authorities decided that money could be saved if the city did its own work, under a special organization, and this opinion appears to be substantiated by the rapid tunneling work noted above.

Within recent years concrete has become a serious competitor with masonry in the construction of long-span arches. At least nine concrete arches with spans ranging from 187 feet to 280 feet have been built on the Continent and in America. Two other notable bridges in the same material are about to be commenced—one of these for the city of Spokane, Wash., containing an arch of 281 feet span, and the other for the city of Pittsburg, having been designed with a 300-foot arch. The Rocky River bridge at Cleveland, Ohio, with the span of 280 feet, is nearing completion at the present time. Several of the structures to which we refer are reinforced to some extent by steel, others being of plain concrete. Although British engineers have not yet attempted any rivalry with their *confrères* abroad in respect of gigantic concrete arches, it must not be supposed that they have neglected the claims of that material in bridge building. Four or five reinforced concrete arches of nearly 100 feet span have already been constructed; a fine highway bridge was completed last year at Pontypridd with a center arch of 117 feet span, and the new bridge commenced at Kilkenny will have the clear span of 140 feet, this being the longest arch in reinforced concrete hitherto undertaken in the United Kingdom.

ELECTRICAL NOTES.

The Allgemeine Electricitaets Gesellschaft of Berlin will construct a transformer which will furnish the highest potential which it has so far been possible to obtain, 500,000 volts; the low tension may be varied between 1,040 and 2,080 volts, the ratio of transformation in this machine is therefore from 250 to 500. The transformer in question is only designed for carrying out investigations on insulation; it is therefore not requisite that it give a particularly advantageous yield of high-tension current. It is of a new type; its low-tension winding is composed of 2 by 44 turns, and its high-tension includes 56 coils; the tension of each coil increases by about 9,000 volts. Powerful insulating cylinders separate the two windings. The transformer in question weighs 5,000 kilogrammes and requires an oil bath of 80 liters.

Many farms are too small to warrant the installation of electric plants, and many others lack the water power required for cheap production of electrical energy. In France several agricultural associations have formed co-operative companies for furnishing electric energy to their members, at cost, and to other persons, at a profit. Strictly co-operative companies, which supply only their own members, may receive aid from the government bureau of agricultural improvement. A subsidized company of this kind was founded by the bureau in 1905, with a capital of $2,000. It furnishes current to its members at a small profit, which is employed in the accumulation of a reserve capital. The charges per kilowatt hour are equivalent to about 7¼ cents, for light, and 3½ cents for power. Lighting current is also sold by contract, the annual charges being about $1, $2, and $3 for each lamp of 5, 10, and 16 candle-power, respectively.

Mr. Maximilian Toch has evolved a new theory of corrosion based on experiments performed by Mr. Sperry, who in a paper before the New York section of the American Chemical Society, showed that scrap steel which had been detinned and subjected to a current of low voltage and high amperage in an alkaline solution was immune from further corrosion. An experiment carried out by Mr. Toch on these lines was the electrification of sheets of steel in solutions of known strength of sodium carbonate by means of currents properly measured. In every instance it was found that where the voltage was low and the amperage high, the cathode plate was protected, except where the solutions were weak, and on the side which faced the anode, and where the electricity naturally left, the corrosion would start almost immediately after taking these plates out of the solution. This process may be of commercial value for immunizing bolts, nuts, screws, etc., such as are used in bridges and all exposed structures. We know in common practice that many bolts rust and repel paint, and just as many attract paint and never corrode, so that we may in this find that the immunizing effect of those bolts which do not corrode may be due to the fact that they are cathode and remain so.

Some interesting results have been obtained in recent experiments carried on between the Poulsen station at Lyngby, near Copenhagen, and Newcastle-on-Tyne. It has been possible to telegraph 100 words or more per minute, while between Lyngby and Esbjerg, on the west coast of Jutland, more than 300 words per minute have been telegraphed. The speed of telegraphing depends solely upon the ratio of the energy used to the distance. The sending of the telegrams at these experiments was done by means of an apparatus somewhat similar to that used in rapid telegraphy through cables. A strip of paper, to which the message has been transferred as a series of perforations, passes through the dispatching apparatus, which effects the telegraphing automatically. The receiving apparatus consists of a fine conductor suspended between the poles of a powerful magnet. When the current caused by the arrival of the electric impulse passes through the conductor, the latter is deflected, and, being illuminated by an electric lamp, its movements are recorded on a strip of photographic paper, which travels subsequently through a developing bath, etc., which fixes the record. This arrangement will very materially accelerate the working capacity of the Poulsen system. While a skillful telegraph clerk, operating by hand, dispatches about 30 words per minute, the method referred to can, it will be seen, very greatly increase this number, according to the distance and the energy employed. The experiments have been watched by a number of experts and representatives of the army and navy, and have attracted much interest. Mr. Poulsen's telephone, of which very little has been heard the last year or two, was made use of at the recent congress of the International Association for Testing Materials, in Copenhagen, all the discussion being thus recorded.

SCIENCE NOTES.

If we could trace the origin of some of our most comprehensive and important scientific ideas, it would be found that they arose in the attempt to find an explanation of some apparently trivial and very special phenomenon; when once started the ideas grew to such generality and importance that their modest origin could hardly be suspected. Water vapor will refuse to condense into rain unless there are particles of dust to form nuclei; so an idea before taking shape seems to require a nucleus of solid fact round which it can condense.

No change has been made in the plans of Harvard College Observatory for the transmission of astronomical announcements, newspaper statements to the contrary notwithstanding. All announcements of astronomical discoveries and observations, which are of value and require immediate transmission, if received at Harvard, are cabled at once to Kiel, and telegraphed at cost to all who desire to receive them. A similar distribution of these messages, and of others in which haste is not imperative, is made by mail, without charge, to those who make use of them.

The hookworm disease does not exist north of the Potomac. The American worm must thrive in a certain temperature. It feeds only on the human intestines and is widely prevalent in the South. It enters the system to some extent through the mouth, but for the most part through the skin. It passes through the lungs into the stomach and lodges in the intestines, where it feeds on the mucous membrane, forming a poison which, while rarely fatal, renders the victim anemic, retards development, and by lowering his vitality makes him easily subject to typhoid, pneumonia, and other more serious diseases.

The boundaries between the sciences are arbitrary, and tend to disappear as science progresses. The principles of one science often find most striking and suggestive illustrations in the phenomena of another. Thus, for example, the physicist finds in astronomy that effects he has observed in the laboratory are illustrated on the grand scale in the sun and stars. No better illustration of this could be given than Prof. Hale's recent discovery of the Zeeman effect in the light from sun spots; in chemistry, too, the physicist finds in the behavior of whole series of reactions illustrations of the great laws of thermodynamics, while if he turns to the biological sciences he is confronted by problems, mostly unsolved, of unsurpassed interest.

Red stars are more numerous than they are generally believed to be, but since they are generally small in magnitude, everyone is not able to see them; that is a privilege reserved for astronomers, who are fortunate possessors of powerful instruments. Some regions of the sky seem to be specially favorable for this purpose. At the observatory of Arequipa there has been discovered one of these regions, where there is found a remarkable group of 29 of these stars, all of which are more brilliant than the tenth magnitude; four of them are double stars. The region of the sky where this discovery has been made is on the border of the Milky Way, and in the constellation of the Scorpion. It is limited in right ascension by 18 h. 48 m. and 19 h. 29 m., and in declination by — 13 deg. and — 23 deg.

There exists in Berlin an anemometer which has been located since 1884 exactly in its present position on the tower of the Joachimsthal Gymnasium. The anemometer, located about 1.7 meters above the parapet of the tower, is about 32 meters above the ground. But the tower, which in 1884 was erected in a space which was free for some distance on all sides, began to be surrounded, little by little, by edifices erected to various heights, averaging from 22 to 25 meters. Under these conditions the wind was found to be progressively weakened in force, as is demonstrated by the following figures, which indicate the average velocity of the wind in meters per second for each of the periods given:

Dates.	Velocity.
1884 to 1888	5.44 meters.
1889 to 1893	4.80 meters.
1894 to 1898	4.04 meters.
1899 to 1903	3.82 meters.

One perceives by this typical case what a considerable influence the construction of high buildings has upon the aeration of masses of humanity.

TABLE OF CONTENTS.

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con-
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29

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of
But
ich
be
ari-
der
ely
ing
ind

ble
oon

ACE
381
382
370
380
380
376
378
379
372
383